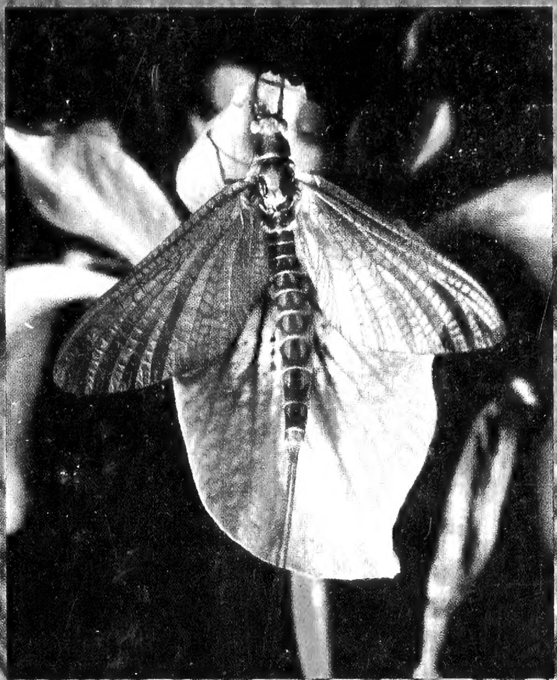

Illinois Wetland Restoration & Creation *Guide*

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*Illinois Natural History Survey
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Illinois Wetland Restoration and Creation Guide

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Introduction

The Illinois Wetland Restoration and Creation Guide is intended to improve the quality and success of restored and created wetlands. It emphasizes the overall restoration and creation process and presents information that serves as a basis for making decisions for completing each stage of a wetland project. The information is applicable to Illinois' natural wetland systems, gleaned from various published sources and from the authors' experience.

Throughout the guide *wetland restoration* means the re-establishment of a wetland in the landscape where a wetland existed historically. *Wetland creation* describes construction of a wetland where none has occurred. *Planned wetlands* refers to restored and created wetlands collectively.

This guidebook has been written primarily for wetland managers in Illinois, and therefore is somewhat technical in nature. Users who will benefit most from this guide are those who have a background in botany, biology, hydrology, pedology, civil engineering, or landscape architecture. The most successful restoration and creation effort will be accomplished by an interdisciplinary team that includes specialists in these disciplines.

Wetlands are an essential feature of the Illinois landscape. The state supports a variety of wetland types, including wet prairie, marshes, floodplain forests, and swamps. Prior to European settlement, these wetlands covered at least 23% of the surface area of the state, an estimated 3.3 million hectares (8.2 million acres). Over the past two hundred years, however, wetlands have been drained, cleared, filled, polluted, and modified to accommodate the demands of human settlement. As a result, wetland acreage has been decimated. By the 1980's, only 371,414 hectares (917,765 acres) of the state's original wetlands (2.6% of the state's surface area) remained, and many of the remaining wetlands have been degraded by sedimentation and other forms of pollution. Wetland losses in Illinois continue at about the national rate of 0.5 percent annually (Havera *et al.* 1994). For a thorough introduction to wetlands and a discussion of their status and trends in Illinois, see Havera *et al.* (1994) and Suloway and Hubbell (1994).

Wetlands, however, have also been recognized as a valuable resource. The functions of wetlands include flood flow alteration, sediment stabilization, nutrient removal, production export, and biological diversity. While the consequences of losing wetlands have not been thoroughly studied, awareness of the benefits wetlands provide has led to efforts to restore and rebuild Illinois' wetland resource. In the Midwest, during the early 1900's, landscape architect Jens Jensen captured the aesthetic appeal of wetlands when he constructed a "prairie river" in Chicago's Humboldt Park (Miller 1915). For decades, federal and state agencies have provided expertise and guidance in creating ponds for livestock and fishing (see Allen and Lopinot 1970; USDA-SCS 1982). Wildlife biologists and land reclamationists have constructed impoundments for waterfowl habitat and hunting purposes (Linde 1969; Payne 1992). Basins have been created by landscape architects and civil engineers to detain stormwater flow and treat municipal sewage. Although most of these sites would not be classified as wetlands under modern definitions, this work has laid the groundwork for further development in wetland science.

In addition, the regulatory community has acknowledged the importance of wetlands and has created a setting for wetland protection. Section 404 of the Clean Water Act of 1972 prohibits the deposit of dredge and fill materials into waters of the United States, including wetlands. The U.S. Army Corps of Engineers (USACE) administer Section 404 regulations for development projects subject to this section. The permitting process requires that mitigation procedures be followed in order to avoid or minimize wetland impacts. When wetlands are destroyed, their loss must be compensated.

Current federal regulations require that three conditions be met for an area to be designated as a wetland and protected under Section 404. Wetlands must have hydrophytic vegetation, hydric soils, and wetland hydrology. Hydrophytic vegetation is "plant life that occurs in areas where the frequency and duration of inundation or soil saturation produce permanently or periodically saturated soils of sufficient duration to exert a controlling influence on the plant species present." A hydric soil is "soil that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part." Wetland hydrology refers to "hydrologic characteristics of areas that are periodically inundated or have soils saturated to the surface at some time during the growing season." These conditions are further defined in the *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory 1987) and the *Field Indicators of Hydric Soils in the United States* (U.S. Department of Agriculture-Natural Resources Conservation Service and National Technical Committee for Hydric Soils 1995).

In Illinois, the Interagency Wetland Policy Act of 1989 directs state agencies to avoid adverse impacts to wetlands, and to preserve, enhance, and create wetlands to compensate for unavoidable impacts. In the act, "to create" includes wetland restoration and wetland creation as defined in this guide. The goal of the Interagency Wetland Policy Act is to prevent any net loss of existing wetland acreage and functions and to increase both over time. The act is implemented through a State Wetland Mitigation Policy and the development of Agency Action Plans.

The act's Wetland Mitigation Policy states that where adverse impacts to wetlands are unavoidable, the wetland loss must be compensated for through development and implementation of an Illinois Department of Natural Resources-approved Wetland Compensation Plan. Further, compensation may be accomplished through a combination of several means: the restoration of degraded wetlands, acquisition of existing wetlands, and the creation of new wetlands. The policy also states that mitigation credit may be given for needed research on wetland functions, restoration, and creation.

Wetland restoration and creation in the modern sense is the next step in the account of wetlands in Illinois. The current emphasis is to attempt to replicate natural wetland structure and function according to selected ecological principles. Restoration continues to promise the greatest potential for success, and guides to ecologically-based wetland restoration are available for parts of the West Coast (Zedler 1984; Stevens and Vanbianchi 1993), the Midwest (Thompson 1992; Wenzel 1992; Galatowitsch and van der Valk 1994), and the Southeast (Holman and Childres 1995).

The art and science of ecological wetland restoration and creation, however, is still relatively new and the technology incomplete. Many attempts to replicate natural function and form have not been successful. Failures occur because of incomplete planning and design, insufficient pre-construction hydrologic information, erosion, herbivory, invasion by upland plants, and inadequate post-construction site monitoring and subsequent remediation (D'Avanzo 1990; Crabtree *et al.* 1992). Even "successful" planned wetlands do not fully replace the functions or biological and chemical features that have evolved in natural wetlands throughout many years (Mitsch and Wilson 1996). It is extremely important to promote sound science to restore and create systems that function as, and closely resemble, natural wetlands. The process and procedures contained in this document are intended to advance this goal.

This guide comprises six chapters that correspond to stages in the wetland restoration or creation process: planning, assessment, design, construction, monitoring, and management. Because conditions affecting planned wetland projects vary on an individual basis, exact specifications are not provided. Users will need to select procedures that are applicable to their particular project at each stage and should consult natural resources professionals before undertaking unfamiliar procedures. Each chapter essentially can be used independently, and wetland designers and managers are encouraged to use appropriate sections of this document as a reference in the field.

• Chapter 1, "Planning for Wetland Restoration and Creation," discusses setting goals, objectives, and performance standards for a project based on desired functions and community type, and selecting potential sites. A description of regulatory considerations concludes the chapter.

• Chapter 2, "Site Assessment," presents procedures for identifying physical and biological characteristics of both natural wetlands and potential planned wetland project sites and relates these characteristics to wetland functions.

• Chapter 3, "Designing Restored and Created Wetlands," reviews general principles for establishing a wetland and guidelines for restoring or creating a wetland that performs one or more desired functions. Design elements are also described.

• Chapter 4, "Constructing Wetlands," provides information and guidance to promote proper implementation of the project design.

• Chapter 5, "Monitoring Restored and Created Wetlands," provides guidelines for developing a monitoring plan, carrying out particular monitoring tasks, and providing a final site evaluation.

• Chapter 6, "Managing Wetlands," describes techniques for addressing potential problems in planned wetlands and maintaining a wetland so that it continues to perform intended functions.

Chapter 1 Planning for Wetland Restoration and Creation—Summary

This chapter describes the fundamental components of a wetland project plan. The discussion for each component provides guidelines and resources useful for developing the plan.

- Goals represent the project purpose. This guide focuses on wetland functions.

- Objectives provide a more specific description of site features that will promote accomplishment of goals. Site features may include, for example, community type, substrate characteristics, or size.

- Performance standards are threshhold values or criteria for a particular aspect of a wetland component and are used to determine the success of a planned wetland project.

- A general description of the methods that will be used to restore or create wetlands are part of the project plan.

- The wetland project site must be compatible with project goals. This chapter includes procedures for selecting a site.

- Planned wetland projects carried out as compensation for wetland loss must comply with certain state and federal guidelines. The final section of this chapter highlights details that should be considered during the planning stage.

The cases below describe example situations in which a wetland designer or manager would use this chapter. Not all situations require users to follow all steps described. For the cases described below, we suggest the appropriate section at which to begin.

• **Case 1** Project goals, objectives, and performance standards must be determined, and a site must be selected: Follow the procedure as presented. If the project is regulatory and replacement of functions is required, a site assessment of the wetland to be impacted should be conducted prior to disturbance to determine the original functions (see Chapter 2). This information is useful in formulating goals.

• **Case 2** Project goals, objectives, and performance standards have already been determined, but a site must be selected:
Follow Sections 1.4, "Methods of restoring and creating wetlands," and 1.5, "Site selection," before proceeding to Chapter 2. This is appropriate when, for example, a wetland is to be established as compensation for wetland impacts elsewhere, and the functions lost must be replaced. It also may apply when a private conservation organization is able to purchase land for wetland establishment.

• **Case 3** A site has already been selected, but goals, objectives, and performance standards must be determined:
Follow the guidelines described in Sections 1.1 through 1.4. This option may be appropriate for landowners who have a suitable site for a planned wetland, but have not yet determined the functions on which to focus their establishment efforts.

Chapter 1 Planning for Wetland Restoration and Creation

Developing a project plan is the first step in restoring or creating a wetland. A well-prepared wetland project plan provides the basis for decision making throughout the restoration and creation process. In this chapter, each section is a short discussion about individual components of a wetland plan. In the first three sections we discuss what to consider in formulating goals, objectives, and performance standards, all of which focus on particular wetland functions and community types. Next, we discuss options for choosing appropriate methods for wetland establishment and offer a procedure for selecting a site that is compatible with project goals. The final section highlights details concerning regulatory compliance that should be considered during the planning stage. A useful reference for planning is *Wetlands Engineering: Design Sequence for Wetlands Restoration and Establishment* (USAEWES 1992b).

Planned wetland project activities may elicit the need for certain permits. Before beginning any project, consult the regional U.S. Army Corps of Engineers (USACE) district, the Illinois Department of Natural Resources (DNR) Office of Water Resources and Wetlands Programs administrator, and the Illinois Environmental Protection Agency (EPA) Division of Water Pollution Control for advisement (see Appendix B, Natural Resources Agencies). Contact local agencies concern-

ing any county or local ordinances that may affect project plans.

1.1 Setting goals

The goal is the general aim or purpose of the project. Table 1-1 briefly describes the wetland functions addressed in this guide. Each project should target restoration or creation of at least one wetland function. Site assessments can be conducted to determine the functions of undisturbed wetlands in the local area (see Chapter 2, "Site Assessment"). Results of the assessment should be interpreted along with additional regional information to determine the most important functions to replace.

Resources useful for setting goals are described in Table 1-2. Appendix C, "Resource Materials and Sources," contains information on how to obtain these materials. *Wetland Resources of Illinois: Analysis and Atlas* (Suloway and Hubbell 1994), watershed maps (Figure 1-1), aerial photographs, and local land use information and zoning requirements provide insight into current wetland conditions and needs. National Wetlands Inventory (NWI) maps (Figure 1-2), the Natural Divisions of Illinois (Figure 1-4), and presettlement vegetation maps can be used to determine the character of wetlands native to the region.

In human-influenced landscapes, replacement of wetland functions may not be possible because of limited space on-site, limited availability of alternative sites, and altered landscape features that prevent performance of a particular wetland function (Davis 1994). The wetland designer or manager might then set goals based on important regional wetland functions. For non-regulatory projects, the wetland functions selected depend on the contemporary landscape in which the wetland project is to occur, *i.e.*, the functions targeted by the project should address particular needs within the watershed. If two or more functions are being considered for a single wetland, the functions must be compatible with each other. For example, production export and sediment and toxicant retention require that inverse processes occur. Tables are available that depict compatibility of functions (Adamus *et al.* 1987; Marble 1992).

Wetland designers and managers should also consider the amount of difficulty with which the function is likely to be replaced. Some functions rely on wetland features that require many years to form. Also, differences exist in the amount of basic scientific information available about the various functions and in the facility and cost to create each (Kusler and Kentula 1989). Some examples follow.

• Flood flow alteration functions can be restored or created with some degree of certainty and ease. Literature about creating open water wetlands is readily available, and topography can be manipulated to provide this function.

• Ground water recharge is difficult to restore or create. Many areas in Illinois are not suitable for ground water recharge because the water table is at or above the level of the wetland. Although ground water recharge can be established in initial stages of wetland development, over time the effectiveness of this function may diminish as sediments accumulate and slow the percolation of water through the substrate of a wetland. Ground water discharge occurs in some types of Illinois wetlands, such as fens, seeps, and springs. However, in these situations ground water discharge is an aspect of wetland hydrology rather than an actual function of the wetland.

• Biological diversity and abundance and particularly waterfowl habitat can be restored or created with considerable confidence. Extensive practical experience, scientific knowledge, and information on marsh design for this purpose are available.

• Visual aesthetic functions, depending on wetland type, may be restored or created with relative success. Design for the visual essence of a wetland is easier to achieve than less apparent ecological functions.

• Natural heritage functions develop with the passing of time. Creating this function is impossible in the short term. However, restoring degraded natural wetlands, especially those that are rare community types or that provide habitat for threatened or endangered species, is possible.

1.2 Defining objectives

Objectives are more specific means to reach a goal. The objectives generally describe particular conditions that must be present in the wetland in order to achieve the stated project goals. Community type, hydrologic regime, vegetation or substrate characteristics, and size of the planned wetland may be included. Any or all of these conditions may be determined specifically by project goals. For example, a project goal may be to create habitat for the state threatened Illinois chorus frog (*Pseudacris streckeri illinoensis*). Specific objectives might state: 1) create open water wetlands that are shallow enough to freeze completely in the winter, or are ephemeral and hold water from March through June; 2) construct wetlands in a high water table with a sand substrate; and 3) provide a buffer of sand prairie.

Wetland community type is a key objective that should be a part of any project plan. Two wetland classification systems commonly recognized in Illinois are the National Wetlands Inventory (NWI) and the Illinois Wetlands Inventory (IWI), and both can be used to identify the type of wetland that may be desired. Neither system was intended to delineate jurisdictional wetlands because their criteria for defining wetlands differs

(Continued on page 7)

Sidebar 1A:

Plant and wildlife wetland dependence

Wetlands are important natural communities that provide habitat, a place where plants and wildlife find food, shelter, protection from enemies, and resources for reproduction. The Illinois Natural Areas Preservation Act (IL Compiled Statutes 525ILCS30/2) states the rationale for saving examples of our native landscape, including wetlands:

"Natural lands and waters together with the plants and animals living thereon in natural communities are a part of the heritage of the people. They are of value for scientific research, for teaching, as reservoirs of natural materials not all of the potential uses of which are now known, as habitats for rare and vanishing species, as places of historic and natural interest and scenic beauty and as living museums of the native landscape wherein one may envision and experience primeval conditions in a wilderness-like environment. They also contribute generally to the public health and welfare and the environmental quality of the State."

Approximately one-third of Illinois native and non-native flora (952 species) is composed of wetland species, and 42% of the native flora (862 species) is considered hydrophytic. One hundred sixty species (19%) of the native wetland flora are listed as endangered or threatened in Illinois (Herkert 1991, 1994).

Of the 274 commonly observed bird species in Illinois, 24 depend on wetland habitats for nesting or foraging sites, and 81 are strongly associated with wetlands during their life cycles. The remaining 169 species may use wetlands opportunistically at some time durng the year. At least 46 of Illinois' 58 mammal species use wetlands. In Illinois, 16 species (80%) of salamanders and all 21 anurans (frogs, toads, and tree frogs) use wetlands at least for breeding and larval development; 19 species (46%) of amphibians depend upon temporary wetlands for breeding. At least 47 species (78%) of reptiles in the state use or depend on wetlands, including 15 of 17 species of turtles, and 28 species (76%) of snakes (Herkert 1992, 1994).

Many of the animals that depend on or utilize wetlands are listed as endangered or threatened species in Illinois, including: 31 of the 42 listed bird species, 8 of the 9 listed mammal species, 4 of 5 listed amphibian species, 11 of the 13 listed reptile species, and 12 of the 30 listed fish species. Of the total 49 invertebrate species listed as endangered or threatened, 3 crustaceans and 3 insects are considered wetland species (Herkert 1992, 1994).

Table 1-1. Description and importance of wetland functions addressed in the guide.

Function	Description	Importance
Flood flow alteration	Wetlands store water during and after heavy rainfalls	The potential for destructive flooding is reduced downstream
Sediment stabilization	Wetlands shield soils from erosive forces of concentrated streamflow or wave action.	This is especially important in wetlands located at the edges of lakes and rivers.
Sediment/toxicant removal	Wetlands filter, deposit, or transform water-borne sediments and toxicants.	Processes involved render wetlands as "scrubbers" that effectively improve water quality.
Nutrient removal/transformation	Wetlands act as sources, sinks, or transformers in the overall biogeochemical cycle, *i.e.* the transport and transformation of chemicals in ecosystems.	Nutrients and heavy metals are exchanged with adjacent waters or with waters that pass through the wetland (Nixon and Lee 1986).
Production export	Wetlands produce organic material and eventually transport it into deeper water in the same basin.	Organic material serves as the basis of the food chain. It is consumed by fish and aquatic invertebrates.
Ground water recharge	Ground water recharge contributes to low flow of surface water streams and lakes, and may be used for public and private water supplies.	In Illinois, where glacial till soils are thick, most wetlands occur where ground water discharges. In a few Illinois wetlands, a portion of the surface water that enters a wetland, percolates through the soil to recharge ground water.
Biological diversity	Wetlands provide habitat, *i.e.*, a place where organisms find food, shelter, protection from enemies, and resources for reproduction for wildlife and plants.	A large portion of Illinois plants and wildlife depend on wetlands for all or part of their life cycles. See Sidebar 1A, "Plant and Wildlife Wetland Dependence."
Recreation and aesthetics	Wetlands are places to photograph nature, watch wildlife, and identify plants.	Humans value wetlands for their recreational opportunities, diversity of plants and animals, and scenic qualities. People derive pleasure from viewing these landscapes.
Natural heritage	Along with prairies and forests, wetlands are one component of the presettlement landscape.	Today, less than one-tenth of one percent of Illinois' native landscape remains. Not only are these remnants and the organisms that inhabit them rare or unique, but what is saved today will be all that remains for future generations. See Sidebar 1A "Plant and Wildlife Wetland Dependence."

Figure 1-1. Drainage basins for the evaluation of wetland resources (approved by the Interagency Wetlands Committee, September 1994).

Table 1-2. Resources that can be used to assess regional wetland needs in Illinois.

Resource	Information provided
Wetland Resources of Illinois: An Analysis and Atlas (Suloway and Hubbell 1994)	Provides maps depicting presettlement and present extent of wetlands as a percent of area, by county. Summary data, *e.g.*, total acreage and percent of area by county and hydrologic basin, for wetland community types are also presented in tabular form.
National Wetlands Inventory (NWI) maps	Show wetland areas by type (Figure 1-2). These are organized by 7.5-minute quadrangles, corresponding to U. S. Geological Survey (USGS) quadrangles and are available as hard copy and digital maps. Figure 1-3 explains the coding system.
Watershed maps	Figure 1-1 shows the 25 watersheds developed for use in setting priorities for wetland restoration.
The Natural Divisions of Illinois (Schwegman *et al.* 1973)	Lists the natural communities, including wetlands, for each section within a natural division of the state (Figure 1-4).
Presettlement vegetation maps (General Land Office plats)	Available for several counties in Illinois (Risser 1984). Public land survey notes also can be used to approximate presettlement vegetation (Hutchison 1988).
Aerial photographs	Useful for viewing the surrounding watershed and for estimating land-use and cover-type information. U.S. Department of Agriculture-Natural Resources Conservation Service (USDA-NRCS) county offices usually maintain aerial photographs for the county.
Land-use information and zoning requirements	May be available for the particular area of interest. Wetland managers should contact regional planning commissions or local municipalities and county clerks' offices for this information.

(Continued from page 4)

from regulatory guidelines. The two systems and their use are discussed further in Sidebar 1B.

Additional information for setting objectives is found in the Illinois Natural Areas Inventory (INAI) (White 1978). The INAI has described wetland community types in greater detail, including the distribution of the community within the state, and vegetation structure, species composition, soils, and moisture conditions within the community. Eight natural community types discussed in the INAI are appropriate for planned wetland projects. Descriptions of each community, modified from the INAI, are found in Appendix D, Illinois Wetland Communities. Table 1-3 compares the INAI, IWI, and NWI systems.

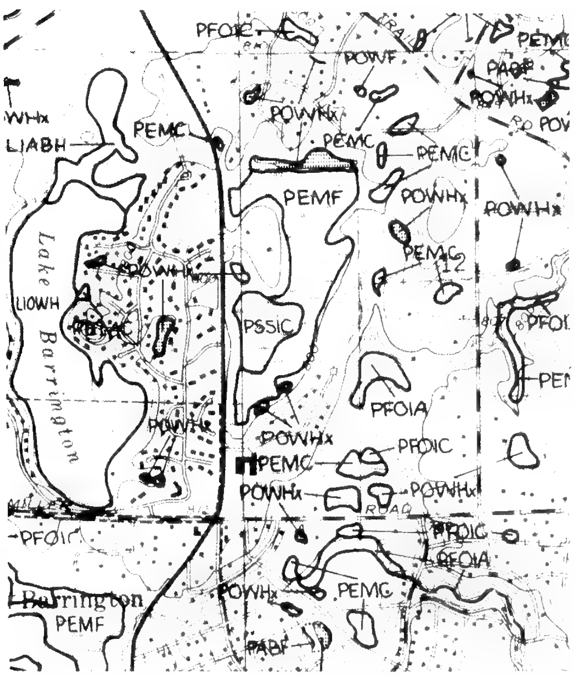

Figure 1-2. Example of a National Wetlands Inventory map showing a portion of the Barrington 7.5-minute quadrangle. From Suloway and Hubbell (1994).

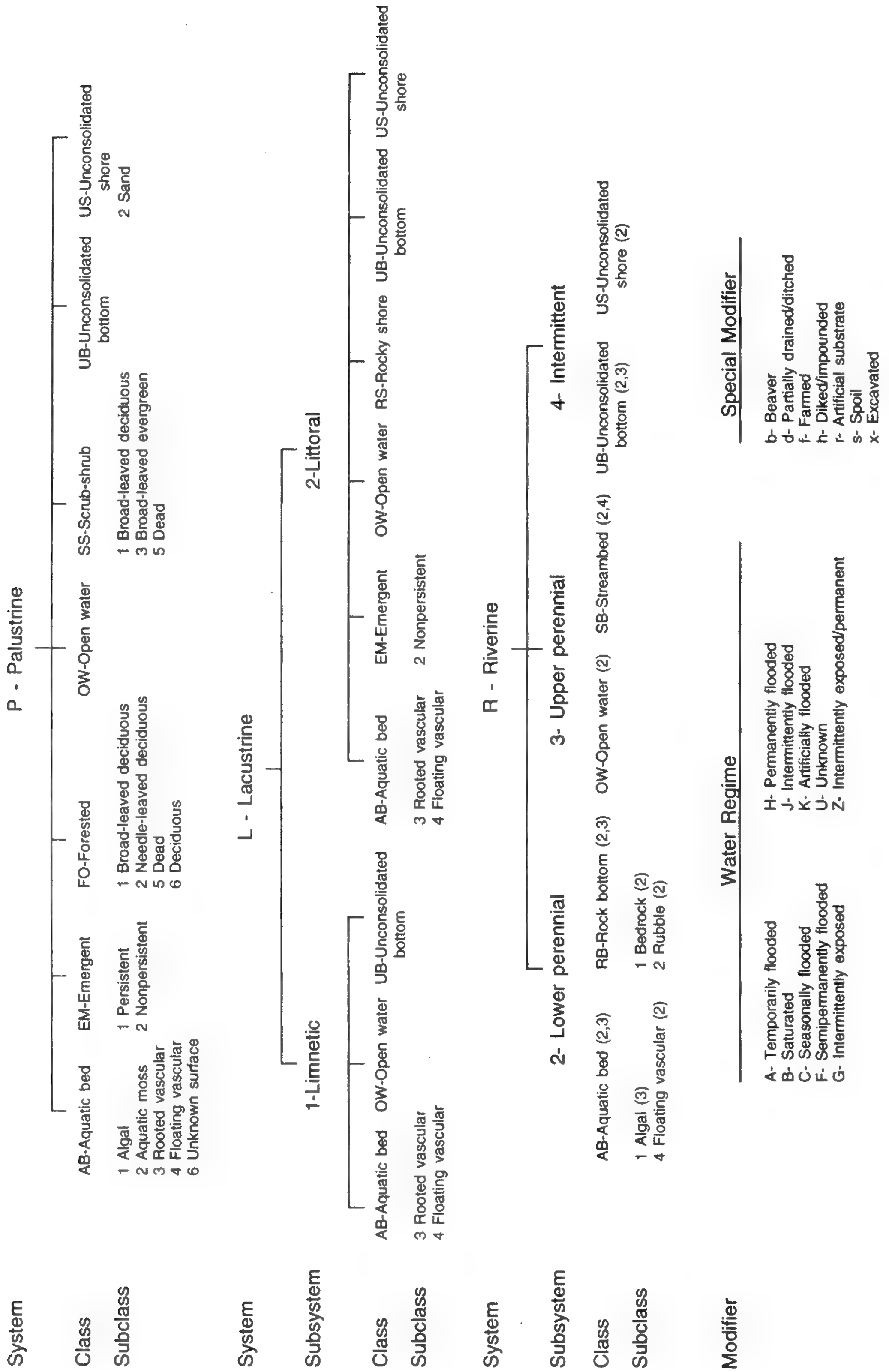

Figure 1-3. National Wetlands Inventory classification system (Cowardin et al. *1979) modified for Illinois. (Numbers after riverine classes and subclasses indicate applicable subsystems). From Suloway and Hubbell (1994).*

Sidebar 1B:
Wetland classification

Two systems commonly used in Illinois to classify wetlands are the National Wetlands Inventory (NWI) and the Illinois Wetlands Inventory (IWI). The NWI project was completed by the U.S. Fish and Wildlife Service (USFWS) to identify and map wetlands and deepwater habitats. In Illinois, wetlands were identified and classified using high-altitude aerial photographs taken from spring 1980 through spring 1987, along with other sources of data, such as USGS 7.5-minute topographic maps and USDA-NRCS soil surveys. An example of an NWI map is shown in Figure 1-2. NWI classification codes describe ecological and physical characteristics, such as dominant vegetative form, substrate type, hydrology, and human effects. The classification used by the NWI was developed by the USFWS and is described in *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin *et al.* 1979). It is hierarchical and includes systems, subsystems, classes, subclasses, and dominance types, with modifiers to indicate hydrologic characteristics and human impacts (Figure 1-3).

The IWI classification system was developed to facilitate use and presentation of the NWI wetlands inventory data. This system combines the 617 unique NWI codes applicable in Illinois into 13 basic groups that reflect the dominant wetland and deepwater habitat types in Illinois. *Wetland Resources of Illinois: An Analysis and Atlas* (Suloway and Hubbell 1994) describes the status of Illinois wetlands according to this classification.

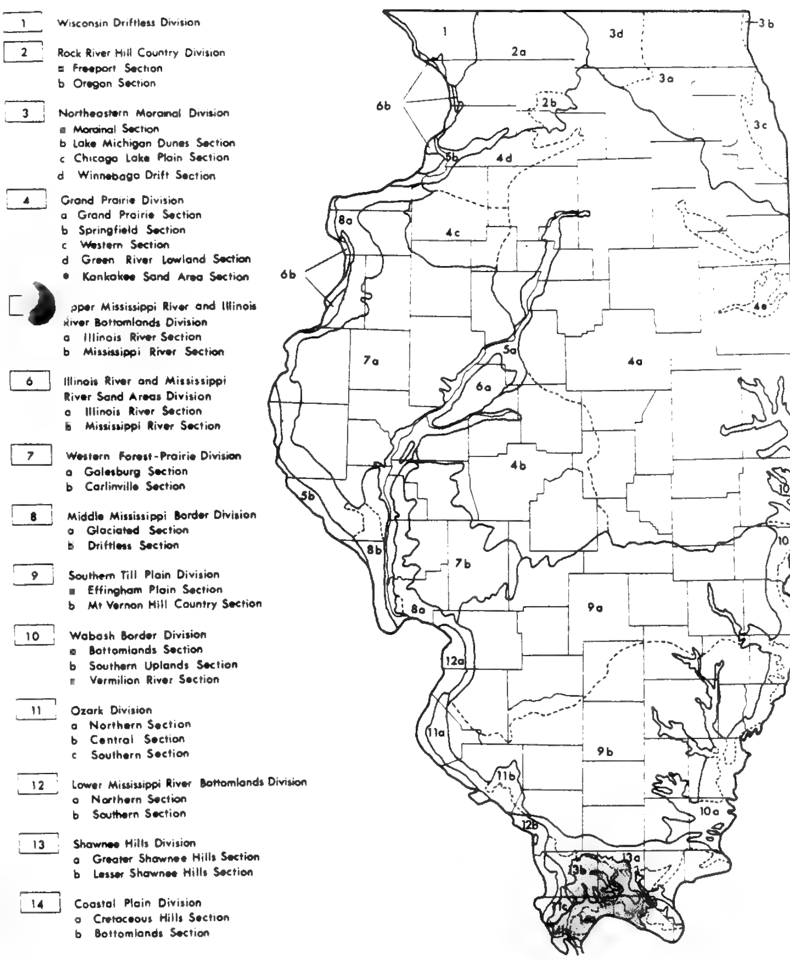

Figure 1-4. The Natural Divisions of Illinois (Schwegman et al. *1973).*

1.3 Establishing performance standards

Performance standards define project goals and objectives in terms of quantifiable parameters in order to determine whether or not the goals and objectives are attained within a specified time period. The standards are threshhold values or criteria for a particular aspect of a wetland component. If measured parameters for the given components meet these standards, the wetland is likely to achieve the goals and objectives, *i.e.*, the project is a success. If performance standards are not met, the wetland project is likely to fail to meet those goals and objectives.

For example, a possible project goal may be to create habitat for the black-crowned night-heron, an endangered species in Illinois. An objective would be to create a marsh that has a hemi-marsh configuration (for an explanation of hemi-marsh, see Chapter 3, Section 3.2.4, "Natural land form"). Performance standards might include the following: 1) presence of at least two groups of invertebrates as a food source, and 2) vegetation-water interspersion of 50% emergent vegetation and 50% open water.

Performance standards should be specified to be reached by the end of the monitoring period (see Chapter 5, "Monitoring Wetlands"). Although annual, increasingly stringent performance standards could be specified for each year of the monitoring period, planned wetland community development on an annual basis is quite variable. The variation occurs because of unpredictable weather patterns, uncertain hydrologic cycles, and differing life histories or growth requirements of particular organisms. Therefore overall standards allow for more flexibility in obtaining the desired goal.

Table 1-3. Comparison of Illinois Natural Areas Inventory (INAI), Illinois Wetlands Inventory (IWI), and National Wetlands Inventory (NWI) categories discussed in the Guide. NWI subclasses are noted in parentheses after class names. Refer to Figure 1-3 for NWI subclass and water regime designations.

INAI community	IWI category	NWI classification
	Palustrine	Palustrine (P)
Forest	Forested	Forested (FO) (1,2,5,6)
Floodplain forest	Bottomland forest	Water regime A,B,C,J,K
Wet floodplain forest		
Wetland		
Swamp	Forested	Forested (FO)
Swamp (tree)	Swamp	Water regime F,G,H
Shrub swamp	Scrub-shrub	Scrub-shrub (SS) (1,3,5)
		Water regime F,G,H
Marsh	Emergent	Emergent (EM)
	Deep marsh	Water regime F,G,J,K
	Shallow marsh/wet meadow	Water regime A,B,C
Sedge meadow	Emergent	Emergent (EM)
	Shallow marsh/wet meadow	Water regime A,B,C
Prairie		
Prairie	Emergent	Emergent (EM)
Wet prairie	Shallow marsh/wet meadow	Water regime A,B,C
Sand prairie	Emergent	Emergent (EM)
Wet sand prairie	Shallow marsh/wet meadow	Water regime A,B,C
Lake and pond		
Pond	Open water	Aquatic bed (AB) (1-4,6), Open water (OW), Unconsolidated bottom(UB), Unconsolidated shore(US) (2)
		Water regime A-H,J,K,U,Z

1.4 Methods of restoring and creating wetlands

The next stage of planning is to describe in general terms how the wetland is to be established. If the project site has already been chosen, the methods must be tailored to site conditions. Alternatively, the wetland designer or manager may be able to specify preferred methods and select a site that accommodates the desired methods (see Section 1.5, "Site selection"). Restoration and creation techniques are discussed in Chapter 3, "Designing Restored and Created Wetlands," and Chapter 4, "Constructing Restored and Created Wetlands."

Restored wetlands have a greater potential to meet project goals, and therefore restoration is the preferred approach. Restoration is less intrusive to the landscape because often one or more essential wetland components are already present or at least existed historically. For restoration projects, the method typically involves removing the mechanism of drainage; filling in a ditch or removing drain tile, for example. The plan may also discuss how existing vegetation will be enhanced or how the site will be revegetated. Finally, the plan may state that fill material must be removed from a buried wetland.

Created wetlands are more difficult to establish because they typically require manipulation of the landscape to produce most of the desired wetland conditions. For wetland creation projects, construction possibilities include excavation, impoundment, or enlargement of an existing wetland. The plan should briefly describe which method will be used and, in general terms, how wetland conditions, *i.e.*, soils, hydrology, and vegetation, will be established.

1.5 Site selection

Site selection is the process of finding an appropriate location to implement the wetland plan. Wetland project goals and objectives must drive the site selection process. Project managers may decide to locate their project in a watershed that has suffered heavy wetland losses. Major Illinois watersheds are shown in Figure 1-1. Planned wetlands will be either restored or created, and guidelines for each option are discussed in Sections 1.5.1 and 1.5.2, respectively. Existing natural communities, *i.e.,* those that have experienced little disturbance, should not be utilized for planned wetlands. Wetland designers

or managers should first seek out sites where wetlands can be restored because this option offers the greatest potential for success. The best site for replacement of wetland functions has all of the landscape features required for the desired functions. If the goal is to restore riparian soil stabilization and wildlife habitat functions, the site must be located on a river floodplain. Similarly, if the goal is to create a wet floodplain forest typical of the Grand Prairie Division of Illinois (Figure 1-4), all uplands and bottomlands in other natural divisions are inappropriate locations. Often, however, suitable sites that display the desired landscape features are not available because of current land use practices, and in reality, site selection is not necessarily directly tied to functions (Davis 1994).

The preliminary characterization of potential planned wetland sites is described in Sections 1.5.3 and 1.5.4. This characterization relies upon information that can be obtained from available materials such as maps and aerial photographs. These materials provide descriptions of soils, hydrology (hydrogeology), and vegetation. From this information, the wetland designer or manager can identify one or more sites that warrant further study as a planned wetland.

Site selection can be completed using assessment procedures found in Chapter 2, "Site Assessment." The assessment requires at least one visit to each potential project location. This is done to verify information obtained from other materials regarding the suitability of potential sites for planned wetland projects and ultimately to determine the site where it is most feasible to accomplish desired goals.

1.5.1 Sites for wetland restoration

The site for a restored wetland must occur where a former natural wetland existed. Initiating a project in undisturbed or natural areas is inappropriate, but disturbed areas where vegetation, hydrology, or soils have been modified are suitable. For example, unvegetated areas with hydric soils are appropriate sites for wetland restoration, although most of these are artificially drained and require restoration of wetland hydrology (Leon Wendte, NRCS, pers. comm). County soil survey reports, county hydric soils lists, and aerial photographs depicting NRCS-designated wetland areas, all available from local NRCS offices (see Appendix C, "Resource Materials and Sources") can be used in combination with information from NWI maps and aerial photographs to locate areas for restoration. Hydric soil map units not identified as wetlands by NWI most likely indicate areas that were wetlands but have been drained. Areas that are incompletely drained, or are frequently flooded, are especially suitable. Hydrology may be more difficult to restore on sites near entrenched stream channels.

1.5.2 Sites for wetland creation

For wetland creation projects, nonwetland areas adjacent to or within 1 km (0.6 mi) of existing wetlands may be preferred because the area probably has a natural water supply. Plant seeds or fragments might be carried in the wind or on the bodies of wildlife and establish vegetation in the newly created wetland. When planning created wetland projects, hydrologic studies should be conducted to ensure that the water regime of existing wetlands will not be affected by project construction activities (see Chapter 2, Section 2.2.2, "Hydrogeological assessment").

County soil survey reports can be used in a number of ways to locate suitable created wetland sites. Tables in soil survey reports describe the suitability of soils for uses such as pond construction. Some soils overlay sand lenses and will not hold water. Somewhat poorly drained soils will require less manipulation than well-drained soils. Sites on gentle slopes (< 5%) are better suited than sites on steep slopes.

1.5.3 Preliminary characterization

Preliminary characterization procedures can be used to identify and describe potential locations for planned wetland projects. This characterization relies upon information that can be obtained from materials such as maps and aerial photographs and can be completed without being present at the potential site. From these materials, one can obtain basic soils, hydrologic (hydrogeologic), and vegetation information, which is fundamental to wetland establishment. The information is used to identify one or more sites that warrant further study as a planned wetland. General procedures are discussed below. After the preliminary characterization has identified one or more potential sites, conditions at each site must be examined more thoroughly during a site visit in order to verify this information. Site assessment procedures are contained in Chapter 2.

1.5.3.1 Soils characterization

Preliminary soils characterization helps locate drained hydric soils potentially suitable for planned wetland projects. These soils offer the best potential for restoration of wetland hydrology and subsequent revegetation with hydrophytic plants. Soils characterization begins with studying county soil surveys and county hydric soil lists as well as NWI Maps, USGS 7.5-minute quadrangle topographic maps, and aerial photography. If possible, note the dates of the maps and photographs. Older documents are more likely to be inaccurate and require a greater degree of field verification. Refer to Appendix C, "Resource Materials and Sources," for how to obtain these materials.

County soil surveys

County soil surveys provide information that is extremely useful for site selection. The soil surveys include aerial photographs overlaid with delineations of soil type, soil taxonomy, and detailed descriptions of texture, color, and characteristics of soil profiles of each soil series. For those unfamiliar with using the soil survey, an additional resource is Broderson (1994).

Potential sites for planned wetlands can be found on map sheets, which are foldout aerial photos located in the back of the soil survey. The index to map sheets, or the general soil map, located in the beginning of the survey, indicates the appropriate map sheet number for the area of interest, *e.g.*, the impacted wetland and surrounding watershed. Each map sheet is overlaid with numerical codes for soil types (mapping units) present. These numerical codes are explained in the Index to Map Units; they refer to the soil series and page numbers where profile descriptions of each series are given. Note that the maps may not be very accurate and therefore soils should always be field verified.

The soil classification or soil taxonomy of mapping units can then be identified. This information is found on the page before the foldouts in the classification of the soils. County or state hydric soil lists will indicate if these mapping units are typically considered hydric. Further soil taxonomy information relevant to planned wetlands is provided in Chapter 2, Section 2.2.2.1, "Level 2 soils assessment."

Quite often, inclusions, or small unmapped areas (less than 0.81 hectares [2 acres]) of a different soil type, occur within larger mapping units. If these inclusions are fairly common within a particular mapping unit, they are typically mentioned in the soil series descriptions.

Tables in county soil survey reports can provide useful corroborative information when determining the suitability of a soil for a planned wetland project. General explanations for the information can be found within the report. A summary below describes the tables in the order in which they typically appear in the soil survey reports. The table numbers shown here in parentheses are valid for more recently published soil survey reports only.

- **Average freeze dates** in spring and fall for a particular county are provided (Table 2). This information can be used to approximate the regional growing season. Growing season is important to determine because the federal definition of a wetland requires that wetland hydrology, hydric soils, and wetland vegetation all be present concurrently during the growing season. While the freeze dates reported here may not be entirely appropriate for wetlands, they are the best information available. The growing season is the period between the last freeze in spring and the first freeze in fall with a probability of 5 or more years out of 10. Hydric soils generally form only during the growing season as a result of the activity of anaerobic bacteria, which are inactive during the winter.

- **Soil types designated as prime farmland** are listed (Table 5). This table also indicates special conditions required for certain soils to meet prime farmland criteria. Prime farmland should be used for planned wetlands only when the site is frequently flooded (*e.g.*, more than one year in two) or incompletely drained. Use of upland sites listed as prime farmland should be avoided.

- A table on **wildlife habitat** (Table 10) provides information on the suitability of a particular soil for wetland plants.

- **Sanitary facility** information (Table 12) relates soil types with suitability for septic tank and absorption fields. Soils that are not suitable for these purposes often are characterized by wetness and slow percolation, qualities necessary for a successful planned wetland.

- **Engineering index property** data (Table 15) provides the USDA texture classification at a given depth. In general, soil mixtures that have a high percentage of fine-textured particles, such as clays, and a low percentage of coarse particles, such as sands, are most suited for wetland purposes. More specifically, soil textural classes such as clay, silty clay, silty clay loam, and clay loam are appropriate substrates. Any soil textural type, even one high in sand content, can remain wet for a long period if it intercepts the water table or receives stream overflow. However, in depressions that collect surface runoff, where the

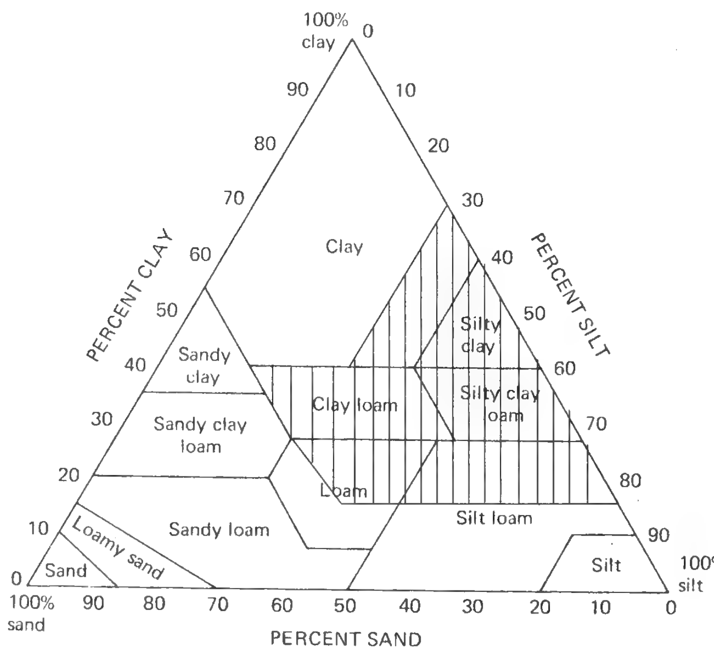

Figure 1-5. Soil textural triangle showing the percentages of the three soil particle components; sand, clay, and silt. Shaded area represents the typical composition of many wetland soils.

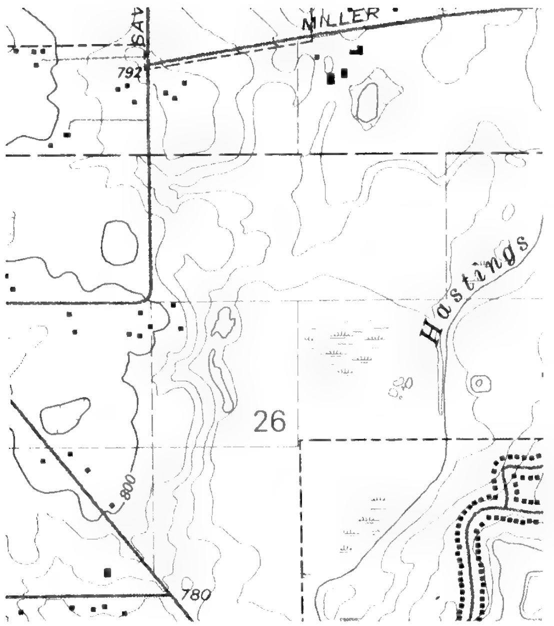

Figure 1-6. Example of USGS topographic map showing a portion of the Antioch 7.5-minute quadrangle.

water table is perched rather than apparent, sandy soils will allow water to percolate downward too quickly to be appropriate for wetland purposes. See Figure 1-5 for an illustration of suitable wetland soil types by percent composition of soil particle size.

- The table, **physical and chemical properties of the soils** (Table 16), provides information on the percent clays, moist bulk density, permeability at a given depth, and percent organic matter. The erosion (K) factor for each soil type is also listed. The K factor is an estimate of soil erodibility by sheet and rill erosion by water, primarily based on percentage of silt, sand, and organic matter (up to 4%) and on soil structure and permeability. K factors range from 0.05 to 0.69; higher numbers indicate greater erodibility.

- The **soil and water features** table (Table 17) provides information on the flooding frequency, duration, and months; high water table depth, kind, and months; and depth to bedrock. Many soils flood in the winter as a result of freezing, which obstructs the downward flow of water, and the absence of respiring vegetation, which prevents water from flowing through the plant to the atmosphere. In spring, however, these soils may be too dry to support hydrophytic vegetation.

Maps and photography

USGS 7.5-minute quadrangle topographic maps provide information at a gross scale about the potential location of suitable soils for planned wetlands, *e.g.*, depressions, drainages, and areas surrounding streams and rivers. Low-lying areas shown on these maps are often accompanied by symbols indicating past or present wetland vegetation (Figure 1-6). NWI maps provide information in the form of encoded symbols representing wetland types present in Illinois (Figures 1-2 and 1-3). See Appendix C for map sources.

In black and white aerial photographs, wet areas such as depressions and drainage patterns appear darker in photo tone than surrounding, more well-drained areas. Inundated land, however, can sometimes appear bright white as a result of reflected sunlight. Aerial photographs taken in the spring show contrasts in tone most dramatically and are useful for locating wet soils. Land features that often appear dark in tone but do not necessarily indicate wetness include freshly tilled land, seen as regularly spaced furrows, and exposed soil heavily trampled by livestock.

With practice, several herbaceous plant communities can be identified fairly reliably using aerial photographs. Matted reed canary grass in a moist meadow appears white or light-colored. Cattail stands and the tussocks in sedge meadows are often evident as well. Forest vegetation, however, often obscures the presence of soil wetness on aerial photographs, unless the photo was taken when trees were leafless.

1.5.3.2 Hydrology (hydrogeology) characterization

The hydrology of a wetland site directly or indirectly influences its functions. The hydrology of an existing wetland or a potential planned wetland site is influenced and controlled by the surface and subsurface geology. In wetland science the term hydrogeology is used to embrace both the hydrological and geologic aspects of a site and therefore will be used in place of hydrology in the following discussion and in Chapters 2 and 5.

The preliminary characterization for hydrogeology includes interpreting available regional and statewide maps and USGS 7.5-minute quadrangle topographic maps (see Appendix C for map sources). The extent of previous hydrologic alteration to the site and its watershed is considered. If aerial photographs are available, a dark, linear tone may indicate locations of tile lines and ditches.

Additional hydrogeologic information can be inferred from other mapped aspects of the area. For example, soil series information can suggest surface material conductivity or retention potential for water, and general geologic maps can suggest expected subsoil material characteristics. The information-limiting factor for some locations is the availability of modern resources such as soil and geologic maps. However, this general level of hydrogeologic information, when added to the other data on soils and vegetation, is a valuable tool in appraising the potential of planned wetland sites and should be completed as early in the planning process as possible.

1.5.3.3 Vegetation characterization

Recent aerial photographs and USGS topographic maps are useful tools for assigning broad vegetation cover types at potential project sites. Vegetation cover type information is valuable for estimating possible buffer areas available and potential impacts to a site from surrounding land use. It can be correlated with preliminary soils and hydrogeology information. Cover type mapping involves categorizing all plant communities (upland and wetland) within the project area, and delineating them on aerial photographs. Cover type descriptions are listed in Appendix E. At this stage it is sufficient to delineate general categories (*e.g.*, forest, grassland, cropland). Marsh symbols and green shading on topographic maps also indicate wet and forested areas, respectively. Detailed cover type mapping is described in Chapter 2, Section 2.2.4.1, "Level 1 vegetation assessment."

The best sites for planned wetlands are low-lying areas where adjacent uplands are relatively undisturbed and can serve as a buffer. Vegetated buffers are effective in cushioning the impact of external forces acting on the system. Often a belt of vegetation is needed to improve the quality of water entering a site, or to serve as a barrier to human disturbance such as trampling of vegetation, soil compaction, and noise (IDNR no date). Vegetated buffer strips can also allow the size of various moisture-dependent plant communities to change naturally in response to fluctuating water levels (Willard and Hiller 1990).

1.5.4 Site accessibility and size

Accessibility and size are additional factors to consider in site selection. If the site is not accessible by road or the terrain surrounding the site is rugged, providing access to it will be expensive. In addition, difficult access makes post-construction monitoring and management more difficult. On the other hand, if a primary function of the wetland is habitat for wildlife and minimal construction activity is necessary, limited human access could be an asset.

Obtaining adequate acreage for a project is important so that planned wetland design will not be constrained by the site size. If enough area is available, the site can support the functions and wetland type specified by the goals and objectives. For example, large, contiguous tracts of land may perform some wetland functions, such as habitat for wildlife, better than small isolated ones. The project designer or manager might also consider factors such as the natural configuration, size, and structural characteristics of the target wetland type as well as recommended buffer width based on land use and landscape features.

1.6 Regulatory considerations

Wetland designers and managers pursuing wetland restoration or creation to mitigate wetland losses are bound by state and federal regulations and must comply with stipulations determined by regulatory agencies. Government agencies planning wetland projects must comply with applicable interagency agreements. These requirements will pertain to various stages of the entire project. Regulations are especially important in the planning stage, and the following guidelines apply to the steps for planning addressed in this chapter. Sample regulatory wetland project documents are contained in Appendix F.

Wetland compensation should be completed prior to or concurrently with the activity causing the wetland impact. The goals developed for most regulatory projects should replace key functions that were lost when existing wetlands were adversely impacted (Section 1.1, "Setting goals"). Each project should target restoration or creation of at least one of the wetland functions that was lost. A site assessment should be conducted to determine the functions of a wetland before the disturbance occurs (see Chapter 2, "Site Assessment"). Results of the assessment should be interpreted along with regional information to determine the most important functions to replace. Designers and managers should also consider the amount of difficulty with which the function is likely to be replaced. In some cases avoiding the impact is a more reasonable mitigation approach than replacing unique or complex wetland functions. Projects require concurrence from the Illinois DNR.

Regulatory project objectives may include community types and acreage based on compensation ratios for mitigation of wetland losses (Section 1.2, "Defining objectives"). Depending on the regulatory agency involved, preference may be given to in-kind wetland compensation, *i.e.*, replacement of one wetland community type with the same type. Acreage compensation ratios are also determined by the regulatory agency.

Performance standards are an essential component of any regulatory project, because these standards will be used to determine compliance (Section 1.3, "Establishing performance standards"). When projects require Section 404 permits, USACE performance standards must be included in the project plan. The following is an example of standards developed for compensation projects by the Chicago District (USACE 1993): "None of the three most dominant plant species in any of the wetland community zones may be non-native species, cattails, or reed canary grass, unless otherwise indicated on the approved mitigation plan."

Of the two general methods for establishing planned wetlands, restoration is often preferred by regulatory agencies because restored wetlands have a greater potential to meet project goals (Section 1.3, "Methods of restoring and creating wetlands"). Restoration proposals are typically awarded lower compensation ratios. Created wetlands are more difficult to establish because they typically require manipulation of the

landscape to produce most of the wetland conditions desired. Greater compensation ratios are usually required for created wetlands.

Permitting agencies may specify acceptable site locations for wetland compensation projects. For example, the project site may be limited to a certain watershed or hydrologic basin. The Interagency Wetland Policy Act states that replacement on the same site as the impacted wetland is preferred, with compensation off-site but within the same drainage basin as an alternative. When this is not possible, compensation off-site and in another drainage basin may be acceptable to the permitting agency. Major Illinois watersheds for wetland regulatory considerations are shown in Figure 1-1. For regulatory projects where in-kind compensation is required, finding soil types similar to those within the affected wetland may be possible (Josselyn *et al.* 1989). Similarity in soil type may promote the establishment of a similar wetland community type and related function(s). Refer to Section 1.5, "Site selection."

Project plans submitted to regulatory agencies must provide all items described in agency guidelines. The appropriate agency should be consulted concerning specific requirements, which may include the following:

- general location map of the project site
- detailed plan view of the proposed work, including elevation of normal water level and water depths
- proposed and existing structures, construction limits, temporary easements, and grading plans
- operation, management, and maintenance plan
- anticipated starting and completion dates of the plan

Compliance with state and federal regulations will be necessary during other project stages. Additional items are discussed in appropriate sections in the following chapters. These discussions are especially relevant for, but not limited to, those conducting regulatory projects. In particular, certain assessment and monitoring protocols (Chapters 2 and 5, respectively) for given components, especially hydrogeology and water quality, may be specified in permit conditions. The regulatory agency may require a preliminary design plan and a landscape plan discussed in Chapter 3, "Designing Restored and Created Wetlands." The post-construction site evaluation described in Chapter 4 (Section 4.7, "Post-construction site evaluation") must be submitted to the regulatory agency. Chapter 5 describes essential items such as the monitoring plan (Section 5.2, "Developing a monitoring plan"), monitoring reports (Section 5.5, "Post-construction monitoring tasks"), and the final site evaluation (Section 5.6, "Post-monitoring site evaluation"). Provisions for project maintenance may also be required, and Chapter 6 describes the methods and schedules that may be necessary.

Chapter 2 Site Assessment-Summary

The assessment procedure presented in this chapter can be used to verify the preliminary characterization in the site selection process (Chapter 1, Section 1.5) and to describe existing wetland features and functions before adverse impacts occur.

- Procedures are presented for collecting information on five components important for wetland establishment:
  - — soils
  - — hydrogeology
  - — water quality
  - — vegetation
  - — wildlife

For each wetland component, two levels of assessment are described:

- — Level 1 procedures direct the user to make a series of observations using steps found on field forms. Assessments usually can be completed during one site visit and adequately describe the component of interest for many restoration projects.
- — Level 2 procedures are used to obtain information that generally requires more time, effort, cost, and expertise to complete. Wetland creation projects typically require a Level 2 assessment of one or more components.

- A discussion is provided to address the relationship between the assessment information acquired for each wetland component and relevant wetland functions.

Each case below describes an example situation in which a wetland designer or manager would use this chapter. For each situation, we suggest the appropriate section of the chapter at which to begin.

• **Case 1** Determine the functions of a wetland that will be impacted:
Site assessment of an existing wetland should be conducted before adverse impacts occur. At a minimum, the Level 1 assessment should be completed for all components. The Level 2 assessment may be necessary if functions can not be determined or if particular concern or interest exists.

• **Case 2** Goals and objectives have been identified, but a site must be selected:
The preliminary characterization (Chapter 1, Section 1.5) should be used to locate potential planned wetland sites. A Level 1 assessment of soils, hydrogeology, and vegetation may provide sufficient information to identify suitable sites and eliminate unsuitable ones. If goals warrant, or concern or interest remains, the water quality and wildlife assessments can be performed. A Level 2 assessment of particular components may be necessary to contribute to planned wetland design at the selected site.

• **Case 3** A site compatible with project goals and objectives has been selected and information is needed for planned wetland design:
Information about soils, hydrogeology, and vegetation is essential. If goals warrant, or there is concern or interest, the water quality and wildlife assessments can be performed. A Level 1 assessment of soils, hydrogeology, and vegetation may provide sufficient information for a restoration site, but a Level 2 assessment of soils and hydrogeology will probably be necessary to contribute to the design.

Chapter 2
Site Assessment

2.1 Introduction

This chapter presents procedures for collecting information about components important for wetland establishment, *i.e.*, soils, hydrogeology, water quality, vegetation, and wildlife. Site assessment procedures verify the preliminary site characterization of potential sites for a planned wetland project (see Chapter 1, Section 1.5). These procedures can also be used to describe an existing wetland's functions and features before it is affected by development. The information can then be utilized in developing planned wetland design.

Examination of a particular component must be warranted by the purpose of the assessment (*i.e.*, whether it is used to select a planned wetland site or to describe an existing wetland), the intended project goals and objectives, and site characteristics. Each component need not be assessed at each site. For example, if the assessment is part of the site selection process, a minimum assessment of soils, hydrogeology, and vegetation will be needed. Assessment of additional components may be useful depending on the intended project goals and objectives and particular site conditions. For a characterization of a natural wetland, a more thorough assessment should be performed to identify wetland functions.

For each wetland component, two levels of assessment are described. The levels represent the amount of time, effort, cost, and expertise required for completing a task, as well as the detail of information needed or required. Several procedures are described under each level, and the designer or manager can choose to conduct the procedures applicable to an individual project. Just as each component need not be assessed at each site, each component need not be assessed at the same level.

Level 1 assessment:
- Is used to obtain general information about an existing wetland or potential planned wetland site. Field forms in Appendix G provide guidance for soils, hydrogeology, vegetation, and wildlife habitat assessments.
- Is used when the functions or features of a particular component are easily ascertained.
- Can be conducted by persons who have a general natural resources background.

Level 2 assessment:
- Is used to obtain more detailed information about a particular component.
- Is conducted if the information from a Level 1 assessment is not sufficient to lead the user to accept or reject a potential planned wetland site or to determine features and functions of an existing wetland.
- Generally requires more specialized training. If wetland designers or managers are unfamiliar with any suggested techniques, they should consult individuals who possess the necessary skills. Natural resources agencies are listed in Appendix B.

For each wetland component, a discussion is provided to address the relationship between the assessment information of each component and particular wetland functions. If several components are favorable for performing a particular function, it is possible that the function is a key one for the existing wetland or that the site may be able to support the function. This overall analysis is subjective, and therefore the wetland designer or manager should consult natural resources professionals if questions arise concerning particular aspects of a wetland or about a site's potential as a planned wetland.

In some situations, assessment of existing wetlands or potential restoration sites will be used to establish standards or baseline information for comparison with the planned wetland. If repeated visits are necessary to obtain sufficient data or to track variation of a feature through time, refer also to Chapter 5, "Monitoring Restored and Created Wetlands."

Additional considerations when assessing existing wetland sites include the following:

• *Can the natural wetland community be replaced if adversely impacted?*
Several natural wetland communities including bogs, fens, seeps, and sedge meadows are extremely sensitive to ecological disturbance, such as changes in water quality or alteration of a predictable cyclic hydrology. From a practical and technical point of view, bogs, fens, and seeps cannot be replaced. These natural communities are dependent on a unique interaction of landscape position, soils, and hydrogeology, and are very specific habitats. In addition, any wetland type with rich species diversity is difficult to replace. Emergent marshes dominated by weedy species such as cattail (*Typha* spp.) or common reed (*Phragmites australis*) are relatively easy to replace; however, establishing higher vegetative diversity is desirable.

• *Do threatened or endangered species occur, or is habitat for threatened or endangered species present at the site?*
The presence of threatened or endangered species in a natural community can be a measure of ecological condition. Many of these plants or animals survive only in very specific environments, such as those with high water quality. The presence of a threatened or endangered species in nearby similar habitat may increase the likelihood that the species occurs within the project site. Often a threatened or endangered plant or animal can be overlooked during the site survey because it is infrequent or inconspicuous. Similarly, even though a site may be ecologically intact and contain uncommon habitat types suitable for rare species, no individuals may be present when the assessment is made. In this case, the conclusion of the assessment is that suitable habitat is present, even though the species itself may not be known to occur there.

2.2 Assessment tasks

2.2.1 Soils

Soils assessment should be conducted to confirm the information gathered during preliminary soils characterization for site selection (Chapter 1, Section 1.5.3.1) and to assess an existing wetland's functions and features.

Level 1 soils assessment:
- Includes locating hydric soils and making general observations of soil wetness.
- Is useful for an initial site visit and sufficient when soil wetness indicators are obvious.
- Can be performed by those with a general natural resources background.

Level 2 soils assessment:
- Involves identifying hydric soil characteristics and performing selected soil analyses.
- Is used when soil wetness indicators are less apparent or when specific information is required for planned wetland design.
- Requires soil science skills.

2.2.1.1 Level 1 soils assessment

Tasks in this section include locating hydric soils using available maps, published soils information, and aerial photographs; and making observations at a site. The first step of this assessment is essentially the same as the preliminary soils characterization (Chapter 1, Section 1.5.3.1) and can be conducted without being present at the site. If this step has already been completed, move on to the procedure for site observations. Site observations are qualitative observations useful for confirming information gathered in the preliminary characterization.

Locating hydric soils

The purpose of this task is to locate drained hydric soils potentially suitable for planned wetland projects. These soils offer the best potential for restoration of wetland hydrology and subsequent revegetation with hydrophytic plants. County soil surveys and county hydric soil lists, NWI Maps, USGS 7.5-minute quadrangle topographic maps, and black and white aerial photography can be examined. Refer to Appendix C, "Resource Materials and Sources," for information on how to obtain these materials. The procedure for using these materials is provided in Chapter 1, Section 1.5.3.1, "Soils characterization."

Site observations

The observations made during this procedure reveal the potential or ability of a soil to act as a suitable wetland substrate. This information can serve as a basis for comparison of multiple sites if a choice must be made between potential sites and provides a reference for Level 2 soil assessment. A field form for this exercise is found in Appendix G. It should be filled out as completely as resources and expertise permit. The field form serves as a record for background information and as a checklist for indicators that hydric soil conditions are present or can be developed. For example, notable features include landscape position, proximity to a flood-prone body of water, and current soil wetness. Cracked soil surfaces, stunted or absent crop growth, and deep tire or foot imprints all indicate soil saturation earlier in the season. Soils that emit a strong sulfur smell (like rotting eggs) or shake (like jello) when walked upon indicate the persistence of wet conditions throughout the year.

2.2.1.2 Level 2 soils assessment

Level 2 tasks that may be necessary include hydric soil determination, and analysis of soil texture, soil compaction, percent soil organic matter, and soil chemistry. A soil scientist can advise the wetland designer or manager concerning which of these analyses is necessary.

Hydric soil determination

The hydric soil determination described in this guide follows the "routine on-site hydric soil determination" described in the *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory 1987). Hydric soil determinations must be made in the part of the soil profile that interacts with living plant material, *i.e.*, the top 25 to 30 cm (10 to 15 in), or, in Mollisols, at the top of the B horizon. The determinations have two components: 1) estimation of soil color, and 2) identification of other hydric soil indicators. Before conducting a determination, one should contact the local NRCS office to obtain the most current version of the report *Field Indicators of Hydric Soils in the United States*. This report is published by the NRCS in cooperation with the National Technical Committee for Hydric Soils and is updated periodically to provide new information about hydric soil colors and field indicators.

Soil textural analysis

Soil textural analysis may be necessary to determine how quickly water moves through the soil and whether the soil will hold enough water for a planned wetland. Textural analysis can have both a field and laboratory component. In the field, this may require extensive soil probing to determine the spatial extent of sand lenses, or other subsurface features which may diminish or enhance the water holding capacity of the soil. In the laboratory, textural analysis involves determining the percentage distribution of particle sizes (clay, silt, and sand) present in the soil. A soil with greater than 15% clay and less than 50% sand is likely suitable for planned wetlands, although an extremely high clay percentage may limit plant root growth. Sand percentage should not exceed 50% unless the site experiences excess flooding or a high water table, such as a site adjacent to a permanently flowing stream. Figure 1-5 illustrates common particle size distribution in hydric soils.

Soil compaction

Soil compaction may be a concern in certain potential planned wetland sites. If a site has been subject to heavy machinery use (*e.g.*, row-cropping), plant root growth may be restricted by highly compacted soils. On the other hand, if soils are too porous, they might not hold water for a sufficient duration for the desired wetland type. Determining compaction during the assessment stage is useful only for wetland restoration sites or on creation sites where existing soils will experience minimal disturbance. Alternatively, if considerable earthmoving will occur during the project construction phase, soil compaction must be measured just prior to planting wetland vegetation. In existing wetlands, soil compaction can be measured to provide baseline information. When determining soil compaction for plant growth, the technique most accessible to the wetland manager involves using the penetrometer, a device that

measures the pressure necessary to push a measuring rod into the ground.

Soil bulk density measurements are used for determining soil porosity and are complementary to soil penetrometer readings. Bulk density can be used to determine whether a particular planned wetland site will hold water because bulk density measurements contribute to calculations for hydraulic conductivity, which indicates how fast water moves through soil. Bulk density is a measure of soil weight per unit volume and varies with the amount of air trapped in the sample, *i.e.*, pore size, and the amount of organic matter. The determination procedure is conducted in a laboratory by qualified personnel.

Soil organic matter

Percent soil organic matter content may be important to determine because it provides the energy for soil microbes to create anaerobic conditions that drive the hydric soil formation process. Organic matter also plays a major role in soil chemical reactions that allow adsorption and transformation of toxic compounds. Wet, anaerobic conditions such as stagnant, ponded water favor organic matter accumulation. Dry, aerobic soil conditions and the scouring effects of fast-moving water favor organic matter degradation or erosion.

Organic matter percentage can be estimated in the field by referring to the *Color Chart for Estimating Organic Matter in Mineral Soils in Illinois*. See Appendix C, "Resource Materials and Sources" for information on where to obtain this chart. Typical organic matter content of various wetland types is described in Fehrenbacher *et al.* (1984).

Soil chemistry

In some instances, soil chemistry analysis can reveal indicators of suitability for planned wetlands. Some general information about soil nutrients and other soil properties is available for each soil type from the state NRCS office (see Appendix B, "Natural Resources Agencies"). If necessary, soil samples can be collected in the field and analyzed in the laboratory.

Bulk chemical analysis can also be conducted if the presence of toxic chemicals that could inhibit plant growth is suspected, *e.g.*, a sewage smell is arising from the soil. In some cases, this type of analysis may be required by the regulatory agency. If the source of contamination is, for example, sludge, the analysis can be conducted for trace metals. If pesticides or herbicides are the potential contamination source, then analysis should be conducted for organic chemicals.

Alternatives to bulk analysis include analysis of exchangeable ions and toxic chemical leach potential (TCLP) tests, which are standard tests that may be required by regulatory agencies.

2.2.1.3 Interpretation of soils data for wetland functions

The following paragraphs can be used to relate particular wetland functions to soils data obtained during the assessment. Functions are listed only if a strong relationship with soils exists.

- Sediment/toxicant removal and nutrient removal/transformation: The landform on which a soil has developed is important in determining its ability to remove sediments from water. Soils such as Peotone silty clay loam occur on closed depressions with restricted outlets. These soils have a thickened A or surface horizon, indicating deposition of sediments from upslope. Such soil types are named *cumulic* in the subgroup category of soil taxonomy. Other Illinois soil types, such as Drummer silty clay loam, may have obvious outlets and the surface horizon is not overthickened, indicating a less rapid accumulation of sediments.

Features of the surrounding landscape affect sediment input into a wetland or planned wetland site. Slopes that are flat (less than 3%) or moderate (3 to 8%) contribute less sediment. The K factor (found in county soil surveys; refer to Chapter 1, Section 1.5.3.1, "Soils characterization") for surrounding soils is also important for maintaining water quality. The Minnesota wetland evaluation methodology (USACE 1988) groups the values into categories of increasing erodibility and associated increased sediment load: less than 0.15, 0.15 to 0.32, and greater than 0.32. Other high and moderate sediment generation conditions on the surrounding land should be noted. For example, moderate sediment input can be expected if the surrounding area comprises a mixture of cropland, pasture, and other land uses, and where the wetland basin and tributaries are buffered by natural vegetation. Greater sediment input occurs in watersheds where evidence of marked erosion is present along most of the basin's perimeter, where the primary use of sediment contribution area is intense agriculture (row crops), or where construction areas or excavations exist within 15 m (50 ft) of the basin or one of its tributaries (USACE 1988).

Nutrients, pesticides, heavy metals, and other toxins adsorb to sediments, and therefore sediment accretion is related to pollutant removal (Boto and Patrick 1979). Organic soils adsorb some pollutants and toxicants more tightly than mineral soils, in part because of the greater surface area available (Pionke and Chesters 1973). Soil pH also may be important in determining the soil's ability to remove certain toxicants and nutrients (Pionke and Chesters 1973).

Fine-textured silty or loamy soils are generally better at removing toxicants and nutrients than sandy soil because they allow more water-substrate contact. Coarse grain materials (sand, cobble, rubble, gravel) allow rapid movement of water through them and therefore provide little opportunity for water-substrate contact (Faulkner and Richardson 1989). Finally,

soils in shallow water are better at removing toxicants and nutrients than those in deep water because increased soil-water contact allows for binding of toxicants or nutrients and soil (Nichols 1983).

- Biological diversity and abundance: Soils with fine particles retain nutrients that promote plant growth, although very fine textures may prohibit good water or root penetration. Substrates finer than sands promote aquatic diversity and abundance (Horner and Raedeke 1989).

- Natural heritage: Soils found on sites that contain biological, geological, or other features unique to or rare in the region are important for the natural heritage function (Bartoldus *et al.* 1994). Wetland sites that are regionally unique or uncommon have high potential for restoration or preservation. Upland sites that have such features are not suitable for wetland creation.

2.2.2 Hydrogeology

The primary goal of hydrogeologic assessment or characterization is the identification of water sources, controls, and losses. It is mandatory that the potential site for a planned wetland have enough excess water to form hydric soils and support hydrophytic vegetation instead of upland vegetation. The hydrogeologic assessment can be relatively simple if the site contains obvious sources of water (*e.g.*, springs, seeps, high water table, or low floodplain with seasonal flooding) and geology that is homogeneous in vertical and horizontal directions. As excess water decreases and geology becomes complex, *e.g.*, heterogeneous in horizontal and/or vertical directions, the decision of whether enough excess water exists at a potential planned-wetland site taxes both the available methods and expertise of experienced professional hydrogeologists and hydrologists. It is critical to realize that the hydrogeology of a given landscape is not an isolated characteristic. Hydrogeologic character is the result of the interaction of surface shape and subsurface material conditions, acting in concert with other physical and biological characteristics (*e.g.*, vegetation and soils) that result in the "wetness" of a given site.

Hydrogeologic assessment has been divided into two levels on the basis of the complexity of the site hydrogeology.

Level 1 hydrogeologic assessment:

- Includes an initial characterization using available resource materials plus field observations of hydrology, geology, and landscape.
- May be adequate for areas that are relatively homogeneous in hydrogeologic character and are not too complex in the other characteristics that define the wetland habitat.
- Requires that the user has a general understanding of earth science.

Level 2 hydrogeologic assessment:

- Involves subsurface examination and professional hydrogeologic interpretation for wetland design and monitoring purposes.
- Is used when hydrogeolgic character is more complex and the need for more accurate information is greater, *e.g.*, subsurface boring is needed to characterize geologic materials and/or if wells must be installed to acquire ground water information.
- Is conducted by individuals experienced in hydrogeologic data interpretation. Generally, professional hydrologists or hydrogeologists should be consulted or employed for these activities.

A basic understanding of a site's water budget, in common hydrologic systems that support wetlands, can be a valuable decision tool in the site selection process. Holman and Childres (1995) present an accepted and often used water budget formula,

$$P + SWI + GWI = ET + SWO + GWO + XS$$

where: P = precipitation
SWI = surface water inflow
GWI = ground water inflow
ET = evapotranspiration
SWO = surface water outflow
GWO = ground water outflow
XS = change in storage

A simpler expression of the water budget is,

Inputs - Outputs = Change in Storage

Holman and Childres (1995) emphasize that the following items should be incorporated into the water budget estimates for wetland design:

- All inputs should be conservatively estimated and output generously estimated.
- All units of measurement should be in terms of water depth over the design wetland or related to some reference elevation.
- All surface water inflow and outflow, ground water inflow and outflow, and storage should be estimated.
- Precipitation data should be selected from historical records.
- Monthly estimates of surface and ground water should be represented graphically.

The following discussion of common hydrologic systems for planned wetland water sources is patterned after Pierce (1993) and Holman and Childres (1995). A site that has multiple water sources generally has a higher potential for success and should be used whenever possible. Common sources of water in the Midwest include the following:

Inline stream flow involves grading the banks and floodplains of streams allowing water to spread and flood a planned wetland area. The model is appropriate for ephemeral, intermittent, and perennial streams that do not experience heavy seasonal flow and should be used only in the lowest energy segments of stream channels. The inline model is favored for areas with highly pervious substrates that would not typically support wetland hydrology.

Offline stream flow can be advantageous when the major water source is a stream with steep banks and/or is too energetic or flashy to use an inline system. Excess stream flow is diverted during normal high flows into constructed berms or naturally occurring depressions on higher parts of the floodplain. Excessive erosion and flow velocity must be controlled since this is normally a high energy system that can destroy many wetland types.

Spring and seepage flow is commonly exploited by down-slope excavation to create a basin that will retain water flow. The nature of the aquifer supplying water must be understood; whether it is seasonally perched or is from a continually charged aquifer must be taken into account when planning with this water source.

Surface flow interception pertains to overland flow and requires the balancing of water-supply amounts, soil permeability, berm construction and/or excavation and wetland-type water requirements. Precipitation is included in this system. Structures to manipulate water levels may be required.

Ground water interception normally involves the excavation and interception of a high water table in an area where the ground water is not at the surface. Attention to where the water table is during the growing season and water-depth requirements of expected plants must be balanced. Reasons for failure of a ground water wetland include:

- excessive drought resulting from a design based upon poorly understood water table, and
- highly permeable side slopes becoming droughty during drawdown periods.

Sharing a water supply with an existing wetland is a viable option, but close attention must be paid to elevation, soil permeability, and the method by which water is conveyed to the existing wetland. Two serious drawbacks are possible:

- excavation most often takes place at the wetland/upland boundary, potentially resulting in a dry planned wetland site, and
- clay, silt, and organic matter may be sealing the bottom of an existing wetland and excavation may cause the existing wetland to drain into underlying sediments.

Close attention to the hydrogeology of the existing wetland will help guard against these pitfalls when trying to expand an existing wetland.

Open water fringe areas can be used. Taking advantage of this water source involves:

- protection from wave energy impinging on the emergent fringe, and
- providing appropriate depths and flow regimes relative to the expected vegetation types.

2.2.2.1 Level 1 hydrogeologic assessment

A Level 1 hydrogeologic assessment of an existing wetland or potential planned wetland site confirms preliminary site characterization information (see Chapter 1, Section 1.5.3.2, "Hydrogeology characterization"). If an initial characterization has not been performed, photos, maps, and any other local resource materials should be collected before proceeding; refer to Chapter 1 for an explanation. The regional, generalized data from state maps and/or regional records or documents must be checked for variation on the potential site. Boundaries, depths, and colors of soils or geologic materials are examples of physical parameters that should be physically verified. All directly observable site characteristics that involve hydrology, geology, and landscape should be noted. A field data sheet that lists most of the relevant features in Illinois has been developed for this exercise by the Illinois State Geological Survey (ISGS) (Appendix G). It can be used as presented or modified to fit a given site. The data sheet should be filled out as completely as resources and expertise permit. Along with soils and vegetation information, this information will serve as a basis for comparison of multiple sites if a choice must be made between potential sites and as a reference for a Level 2 hydrogeologic site assessment if one is required. Each item included on the field form is explained below.

The hydrogeologic assessment first requires general observations about current and past land use of the wetland or potential planned wetland site, as well as the surrounding land use. This information provides insight into whether past, present, or future activities have already affected or will adversely affect the site.

The generalized description and identification of subsurface materials (bedrock and the sediments above the bedrock)

should include the depth to different kinds of materials as well as the thickness of these materials, conditions that either inhibit or ease the subsurface movement of water, and the distance from the surface to the water table. Also note any soils information that is available from county soil surveys, the Level 1 or Level 2 soils assessments (Section 2.2.1), or from direct observations. Certain soil features, *e.g.*, hydric soil indicators, suggest a prolonged presence of water.

Information about general site topography is essential for determining water flow through the site. Note the percent slope, flow direction in any channels, relief of the site, and any elevation benchmarks that are located on or near the site. Particular attention should be paid to hydrologic features such as existing wetlands, ponds, stream channels, and ground water seeps. Any feature, natural or artificial, that causes or has the potential to cause a gain or loss of water to the site should be noted, including tile outlets or inlets, and any artificial or natural obstructions to flow. In a Level 1 assessment one should have enough information to estimate whether there will be excess water on the site from some source. When this decision is made, one should consider the seasonal patterns of temperature and rainfall. For example, if the area normally has a long dry season, the site will have to store enough water during the wet season to maintain the wetland during the dry period. Finally, assess the morphology of the existing wetlands, noting the orientation of the wetland in the landscape and its size and shape. Also, record any connections to other wetlands or water sources such as drainage ways or streams.

2.2.2.2 Level 2 hydrogeologic assessment

A Level 2 assessment characterizes site hydrogeology so that the information will be suitable for design. It confirms and builds on information obtained and decisions made during a Level 1 wetland assessment. Details of the Level 2 assessment must be tailored to the needs of the site. Potential data include:

- watershed size
- wetland physical parameters (area, water depth, 3–dimensional basin shape)
- water budget
- wetland hydroperiod
- depth to saturation zone in noninundated areas
- indicators of hydrology as required by the regulatory agency
- vertical and areal extent of surface and subsurface materials

The following parameter discussions are included to provide the nonprofessional with background information that will enable review and decisions that may be required of a landowner or manager from the Level 2 assessment information or reports.

Wetland watershed size

The size of the watershed is calculated from maps of the region containing the wetland. USGS 7.5-minute quadrangle topographic maps are adequate for this purpose. The area that drains into the wetland either directly as overland flow, channelized flow, or by overbank flooding from a nearby stream should be outlined on the map and the total drainage area calculated using either graphic or mechanical methods. This information is necessary to calculate water budgets for a wetland basin.

Wetland physical parameters

Physical parameters are measured directly in the field. The equipment required varies from simple measuring tapes and sounding rods (measuring rods for determining water depth) for small or uniform sites to standard surveying equipment and methods for large or complicated sites. Aerial photographs that have been printed at 1:1200 to 1:4800 scale, depending on the size of the site, are very useful for this task. Depth of any ponded water should be measured with a sounding rod so that the volume of water can be calculated. The density of measurements varies with the complexity of areal shape and depth profiles (Goudie 1981). At the end of this process an accurate contour map of the wetland basin and the immediate area around the wetland should be constructed. A contour interval of 0.3 m (1 ft) is recommended to allow reasonably accurate calculations of elevation and volume required for wetland design. These data will be used to calculate wetland area, water depth, basin shape, and wetland volume for the different seasonal hydrologic conditions.

Field measurements for the various surface water and ground water elevations must be performed at definite time intervals, varying from monthly to multiple data points per sampling location per day depending on the nature of the hydrogeology of a site. Monthly data collection is usually adequate for areas that have a homogeneous geology or have good wetland models in a comparable landscape position located nearby. More complicated geology (multiple material changes either vertically or horizontally) requires more complex data collection design. In locations where water availability will be a limiting factor, short time-interval data collection becomes more critical.

Water measurements that represent only one point in time or one season of the year are not adequate for hydrologic calculations. Information collected throughout four seasons, depicting the variability and duration of water levels over time, is needed for adequate planning decisions. Surface water depths can be measured using staff and crest gages placed within the wetland or contributing surface water source. Staff gages provide current water level readings, whereas crest gages can record the highest water level attained in a given time period. Detailed directions for making and installing staff

gages can be found in Goudie (1981) and Horner and Raedeke (1989). Water velocity measurements must be acquired if the volume of surface water is required. Ground water levels, represented by water table elevations, are most often measured in ground water observation wells. Valid water table elevation data are dependent on precise location and installation procedures. Standard procedures for observation-well installation are shown in ASTM (1990). Shallow observation-well installation in wet areas may require modifications to the standardized procedure. Some of these modifications are illustrated in USACE (1993d) and Miner and Simon (1996). It is critical that observation wells be installed in known subsurface geology and aquifers relative to a potential constructed wetland or restoration site, for the data to be valid for wetland design decisions. Incorrect well design relative to subsurface geology is one of the most common mistakes made during collection of data for wetland design.

The length of time required to acquire meaningful data is a minimum of one year if the year is a "normal" hydrologic year. A longer observation period may be required if abnormally dry or wet periods occur during the initial one-year observation period. Climatological information can be acquired from the state climatologist or the Midwest Climate Information Center, located at the Illinois State Water Survey, to assess the hydrological year (see Appendix C, "Resource Materials and Sources"). A wetland regulatory agency may specify the length of pre– and post–construction monitoring periods if wetland impact mitigation is involved.

Water budget

A primary purpose of a Level 2 hydrogeologic assessment is to identify all sources of water entering and leaving a site and subsequently constructing a water budget for the site. The potential sources of water in a wetland are:

- precipitation
- overland flow, often called sheet flow or slope wash in soils information sources
- channel flow (creeks, streams, or rivers)
- overbank flooding from channels
- a water table that exists within 0.45 m (18 inches) of the surface
- subsurface flow (ground water); usually accumulating in low areas or basins (similar to springs)

Losses of water from a site include:

- evapotranspiration from soils and plants (highly variable with differing seasons, plant types, soil types, and landscape position)
- infiltration to subsurface materials (to either the unsaturated materials deeper than 0.45 m (18 inches) depth or to an aquifer)
- loss by overland or channelized surface flow

The water budget, defined by the above components, is shown in Section 2.2.2. The accuracy required for measurement of the budget components depends on the requirements of the project and the data and finances available. Data used for calculations can range from estimations of all parameters using published soil and climate data to direct field measurements of required parameters over extended periods of time. For example, surface water information for many streams in Illinois is published yearly and can be used to determine frequency of flooding. These data are published by the USGS Water Resources Division and the Illinois State Water Survey (see Appendix C, "Resource Materials and Sources").

Estimation of the budget is the least costly and time-consuming methodology but is prone to inaccuracies. Using methods published by the NRCS (USDA-SCS 1992b), the rainfall in the watershed area can be allocated to infiltration and runoff and the amount of surface water flowing into a wetland can be estimated on any desired time scale. The basin volume (discussed above) is combined with these surface flow and evapotranspiration estimates (available from the state climatologist) to calculate storage and outflow from the wetland basin.

Direct measurements of channelized flow, ground water flow, rainfall, and evapotranspiration can be made over a given time period and the remaining components of the budget calculated. This is the most accurate, costly, and time-consuming method to compute a water budget and should be done by trained professionals.

Wetland hydroperiod

Wetland hydroperiod is defined as the pattern of water depth over time (Mitsch and Gosselink 1993), and it influences the particular biological communities that can exist at a particular time and place. The hydroperiod must be determined for a potential planned wetland site or for a nearby existing wetland that will be used as a model or reference for a potential site. After the site or wetland geometry (size, shape, and volume) and water budget have been determined, the site hydroperiod calculation is an exercise in allocating excess surface water (often referred to as change-in-storage in budgets and models) to evapotranspiration and infiltration/saturation. The calculated result is the time period of inundation or surface saturation for the site.

For example, if it has been determined (using the NRCS TR-20 program [USDA-SCS 1992b] or any other runoff calculation method) that a one-half inch rain event is the minimum that will result in an excess of water in a given area, then the excess water from any event greater than one-half inch is distributed over the potential site as ponded water and allocated to evapotranspiration and infiltration. In the example above, duration of excess moisture (saturation or inundation)

has been calculated for one point in time. Climatic records obtained from the state climatologist or the Midwest Climate Information Center (refer to Appendix C, "Resource Materials and Sources") show the normal average (1961-1990) distribution and timing of rain events occurring in the designated region that produce more than one-half inch of precipitation. The example site hydroperiod can then be estimated by combining the distribution of rain events and the calculated time-duration of excess water. This determines the hydroperiod of existing wetland areas or defines the hydroperiod of the potential planned wetland site.

Depth of saturation zone

Saturated soils or materials that limit the root growth of plants not adapted to growing in wet conditions are one of the defining characteristics of wetlands. The depth of near-surface saturation is found by digging shallow pits in the study area and estimating soil saturation height above the water table by observing soil characteristics or by direct measurement in the field with specialized instruments, and/or by sampling soil materials in the field and determining the moisture content in a laboratory.

Effects of hydrologic disturbance

The natural near-surface hydrology of many areas has been disturbed for agricultural and urban development. When disturbance is detected or suspected it must be documented with historical records or physical site evidence before successful restoration of the hydrology of a site can take place. The complete history of all hydrologic disturbance must be taken very seriously. Overlooking key aspects of disturbance history can be economically costly if restoration efforts fail because drainage features, *e.g.*, drainage tiles, remain active. Common alterations that affect drainage by diverting surface water and/or ground water away from wet areas are tiling, ditching, and channelizing. The infiltration of water into the subsurface is disrupted by urban development such as the presence of buildings and concrete pavement. In both urban and rural settings, "cut and fill" land leveling techniques (the cutting down of topographically higher areas and the filling of low areas) can alter both surface and subsurface drainage.

When a proposal to restore hydrology to a given area is considered, a careful assessment of potential changes in hydrology in the landscape surrounding the site is critical. When structures of any kind are located nearby a proposed hydrologic restoration project, extreme care must be taken to ensure that damage in surrounding areas does not result from rising water tables and/or restored surface water flow. Similarly, if the water table has been lowered by drainage tiles, drainage ditches, or water source diversions, attempts to restore the water table to near-surface elevations may affect the surrounding landscape for hundreds of feet, especially in a down slope or ground water-gradient direction.

2.2.2.3 Interpretation of hydrogeologic data for wetland functions

The following paragraphs can be used to relate particular wetland functions to hydrogeologic data obtained during the assessment. Functions are listed only if a strong relationship with hydrogeology exists.

- Flood flow alteration: Site location and size affect its capability for flood control. If the wetland or planned wetland site is located within the 100-year floodplain, it is more likely to receive and store water from surface flows and release it slowly downstream.

  Generally, the larger the wetland, the greater the ability to store and attenuate flood flows. It is suggested that wetlands larger than 2 hectares (5 acres) are most effective; wetlands 0.2 to 2 hectares (0.5 to 5 acres) in size or those connected to another wetland within a 4.8-km (3-mile) radius by surface water are somewhat less important for this function (Roth *et al.* 1993)

- Sediment stabilization: The location of a wetland is important in determining the importance of this function. Wetlands having large open water areas or that occur on lake shores and river banks are subject to wave action and stream flow and therefore are more important for this function than those that are not subject to highly erosive forces.

- Sediment/toxicant removal: Generally, large wetlands filter pollutants better than small wetlands. However, small wetlands connected via surface water can act as a series of filters and function similarly. For example, wetlands greater than 2 hectares (5 acres) perform this function best, but wetlands between 0.2 to 2 hectares (0.5 to 5 acres) in size or those connected to another wetland within a 4.8-km (3-mile) radius by surface water may also perform acceptably (Roth *et al.* 1993).

  Water velocity during high flows directly affects how a wetland influences water quality (USACE 1988). Open water pools, shallow sheet flow, or multiple flow channels promote sediment and toxicant removal more than highly channelized configurations (Horner and Raedeke 1989). Residence time of water in the wetland should be 36 hours or longer, and flow between inlet and outlet should not be diverted. Low entrance velocity ($\leq$10 cm/s) will prevent resuspension of settled solids, and low flow velocity ($\leq$5 cm/s) will promote pollutant reduction. Relatively shallow depths ($\leq$1 m [3.3 ft]) allow better mixing and aeration to stimulate biological and chemical oxidation of contaminants. Shallow depths also maximize light penetration through the water volume, supporting photosynthetic processes involved in pollutant uptake.

- Nutrient removal/transformation: Retention time, accumulation of organic detritus, and soil type appear to be the most important factors influencing nutrient removal/transformation. More than 90% of inorganic nutrients are retained in the closed systems (those without an outlet) while less than 5% are retained in open systems (those with an outlet). Nutrients turn over more rapidly in emergent/aquatic bed marshes than in swamp forests. Deep water wetlands have a longer retention time than shallow water wetlands, but effluent and sediments experience less interaction because of a high water/soil ratio. Typically, the lower the average depth, the greater the opportunity to enhance water quality (Bartoldus *et al.* 1994).

Removal or retention of specific nutrients may require widely differing conditions. Bartoldus *et al.* (1994) summarize a number of studies that recommend water detention times for a variety of purposes.

- Biological diversity and abundance: The overall hydrologic regime at the site affects the plant and animal communities present. During plant establishment, large water level fluctuations can prevent successful establishment or cause severe erosion of the substrate. Woody vegetation tolerates large, rapid water level fluctuations more readily but may not be able to withstand long periods of inundation.

Emergent vegetation, on the other hand, is less likely to survive extreme water level changes, but many species are adapted to permanently flooded conditions. Appendix P, "Growth and Propagation Requirements of Selected Wetland Plant Species," includes a list of water depth tolerances.

2.2.3 Water Quality

Water quality assessment can reveal important information about potential planned wetland sites and existing wetlands because water quality affects both biological and physical processes in wetlands and may define conditions that may be unique to an individual wetland or wetland community type. For potential planned wetland sites, baseline (preconstruction) information can be used to detect water quality changes within the watershed and wetland after the project is completed. Water quality information for an existing wetland can suggest the wetland's functional role in the local watershed, the nature of hydrologic inputs and outputs, and general wetland condition.

Two levels of water quality assessment reflect both the amount of sampling effort and the intensity of analysis needed.

Level 1 water quality assessment:

- Involves measuring certain water quality parameters in the field.
- Is used when a basic water quality description is needed.
- Can be performed by individuals who have received general training in water sampling.

Level 2 water quality assessment:

- Involves laboratory analysis of selected nutrients and other elements or compounds.
- Is used when a reading of a Level 1 parameter suggests that an atypical situation may be present in the wetland or when a particular location or event suggests a potential problem. This type of information can also be collected in natural wetlands in order to develop performance standards for evaluating planned wetlands.
- Is conducted by qualified personnel. For regulatory projects, water quality analysis may need to be performed in a laboratory certified by the Illinois Environmental Protection Agency (IEPA). Contact IEPA (Appendix B, "Natural Resources Agencies") for information on lab certification.

Implementing consistent data collection procedures is essential for obtaining comparable results in water quality analyses. In this discussion, a water "sample" is the amount of water collected at a specific location to measure and analyze a given set of parameters. The frequency and number of samples taken within a wetland or potential planned wetland site will vary among individual projects, depending on particular wetland features and project goals and objectives. For example, data may be collected monthly or quarterly. Sampling after storm events might be useful primarily if highway salt or petroleum laden runoff is suspected to be entering the wetland. An individual wetland's configuration also affects the sampling design. If major surface inflow(s) and outflow(s) are present, water should be collected from each inflow and outflow, as well as from within the wetland. Areas representative of variation in water depths and associated plant communities can also be sampled (Horner and Raedeke 1989). If the wetland will be sampled repeatedly over a period of time, collecting locations should be marked at the site and recorded on a site map so that they can be found easily.

The types of water present at the site will influence or control the sampling protocols used. Water types applicable for analysis in wetlands can be separated into: 1) standing water, 2) flowing water, and 3) shallow ground water. Standing water may be present only part of the year, or may be up to 2 m (6.6 ft) deep in ponds or basins. Flowing water may range from a spring seepage to wetlands that receive stream or river inflows. Analysis of shallow ground water may be requested for some locations.

Standing surface water is characteristic of many wetlands and is the easiest to sample. The methods discussed in the Level 1 and Level 2 water quality assessments generally apply to standing water. Wetland substrates can be extremely silty, and the water can become very turbid (cloudy) if the person collecting the water disturbs the substrate by walking in the wetland. Turbidity can cause inaccurate measurements and therefore should be minimized. Boats or canoes can be used to reach sampling locations if the water is deep enough. In smaller wetlands, water can be collected with a modified dip sampler by someone standing on the wetland edge. This dip sampler is constructed of a one-liter, wide-mouth, high density polyethylene bottle attached to the end of a 6-ft-long pole (Simon and Cahill 1994).

For sampling flowing water, however, a number of key issues must be addressed prior to the start of the project. For example, if the purpose of the data collection is primarily for screening, then grab samples collected in the center of the flow are probably sufficient. Modified dip samplers may be suitable in small streams. In larger streams, or when sampling from a bridge, a specialized sample bottle, *e.g.*, one that has a weighted messenger that closes the bottle when the sampler is at the desired depth, is useful. Specialized samplers, calibrated stream cross sections, information on stream flow or stage, and some estimate of the suspended sediment load may be needed if mass balance considerations are important.

Shallow ground water sampling for water quality needs to be addressed prior to monitoring well installation. The choice of parameters to be measured and the volumes necessary depends on the diameter of the well installed, the material used in the casing, and how the well is finished. Equipment needed for purging and pumping the well may range from bailers to various types of pumps. If mass balance considerations are important, some estimate of yield may be required. Practical guides to ground water sampling (Barcelona *et al.* 1983; Barcelona *et al.* 1985) are also available.

Additional guidelines for sampling specific parameters are provided within the discussion for each. A useful field reference is the *Pocket Sampling Guide for Operators of Small Water Systems: Phases II and V* (see Appendix H, "Field Guides"). More complete procedures are explained in *Compilation of E.P.A.'s Sampling and Analysis Methods* (Keith 1992).

Results of the analysis are compared with representatives of the same and different wetland types within or outside of the region. Results can also be compared with published or accepted water quality standards, if available, which may be included as a performance criterion for the permit issued for a wetland mitigation project. General use standards are designed to protect water for àquatic life, wildlife, agricultural use secondary contact, and to ensure the aesthetic quality of the aquatic environment. These standards are applied to waters that have no specific designation (IEPA 1995). Table 2-2 lists ranges of values for water chemistry parameters for selected wetland communities in Illinois and general use water quality standards from IEPA (Simon and Cahill 1996). The table includes the number of locations sampled as well as the total number of samples analyzed. Dissolved oxygen, total dissolved solids, silver, and mercury are listed in the general use standards but were not included in this study (Simon and Cahill 1996). Mitsch and Gosselink (1993) and Stevens and Vanbianchi (1993) also list ranges for certain wetland types.

2.2.3.1 Level 1 water quality assessment

Level 1 water quality assessment includes measurement of the water quality parameters pH, temperature, conductivity (specific conductance), and oxidation-reduction (redox) potential (ORP). Measuring these parameters is recommended for nearly all projects for which water quality information is needed. The significance of each parameter is described below.

Water testing kits or electronic field instruments are used to analyze basic chemical parameters in the field. See Appendix C, "Resource Materials and Sources," for supplier information. The kits should include electronic meters or probes for pH, temperature, conductivity or total dissolved solids (TDS), and oxidation-reduction potential (ORP) if necessary. One-liter polyethylene bottles or beakers can be used to collect water in which to insert the probes. Electronic equipment must be calibrated and used as instructed by the manufacturer. Specific instructions for measuring each parameter are provided with the kit. Collection bottles should be rinsed twice with the water from the sampling location (1/8 to 1/4 bottle per rinse) before the water used for analysis is collected. Rinsing will ensure that the measurements represent the water sampled and not impurities contained in the bottle.

- pH: pH indicates the hydrogen ion activity in the water, expressed on a scale of 1 to 14. Neutral pH is 7, acidic conditions are indicated by a pH less than 7, and basic or alkaline conditions are indicated by a pH greater than 7. The pH affects both biological and chemical activities in the wetland; most organisms are adapted to living in near-neutral conditions. pH can provide information about the hydrological inputs to the wetland (Horner and Raedeke 1989). For example, alkaline readings may indicate ground water inputs. pH should be measured in the field, because changes can occur rapidly as a result of biochemical reactions, temperature differences, and gas diffusion.

- temperature: Temperature determines the rates of biological and chemical processes. All aquatic life

responds to temperature variations and usually has limits for optimal growth and development. Water temperature data can provide information about the hydrological inputs to the wetland, *e.g.*, water temperature in ground water-fed wetlands remains relatively consistent regardless of the season. Generally, water temperature does not exceed 2.8˚C (5˚F) above natural temperatures. Higher temperatures suggest that human activities are affecting the wetland.

- conductivity (specific conductance): Conductivity indicates the amount of dissolved solids in the water, measured as the ability of the water to conduct an electrical current. High readings (>2000 mS) indicate the presence of high amounts of dissolved solids in the water and may suggest the presence of soluble pollutants. Conductivity is a good estimator of total dissolved solids (TDS); TDS measured in mg/l is proportional to conductivity measured in micromhos (Hounslow 1995).
  Conductivity is associated with differing solubilities of geological materials, and therefore values differ considerably among geographic areas. In order to determine whether values for the wetland or planned wetland site are typical of the region, collect samples from nearby wetlands, streams, and lakes, as well as ground water, if applicable (Horner and Raedeke 1989). This will help to establish the conditions required for aquatic life native to the region.

- oxidation-reduction (redox) potential (ORP): Redox potential is a measure of the electron pressure (or availability) in a solution (Mitsch and Gosselink 1993). Negative or low values [less than 50 electron volts (ev)] indicate reducing conditions, *e.g.*, where sulfide is present. Values greater than 50 ev indicate oxidizing conditions, which are expected in most natural settings.

2.2.3.2 Level 2 water quality assessment

Laboratory analysis of water collected in the field is conducted for selected chemical parameters. These parameters include the common forms of carbon, nitrogen, and phosphorus, as well as the major cations and anions, total alkalinity, total dissolved solids, and trace elements. Certain nutrients and elements or compounds may serve as markers for point or nonpoint pollutants (Simon and Cahill 1994). If Level 2 assessment is determined to be necessary, a chemist can provide guidance regarding which analyses are appropriate for the particular situation. Because laboratory chemical analysis is expensive, it is not cost-effective to analyze more parameters than will be meaningful.

Occasionally, particular circumstances (*e.g.*, close proximity to industrial areas) warrant laboratory analysis of water samples for trace organic compounds. These trace organic compounds include pesticides, polyaromatic hydrocarbons (PHC), and polychlorinated biphenyls (PCB). Chemists can provide advice concerning appropriate analyses.

For a Level 2 assessment, water samples are collected in polyethylene bottles as described for Level 1. Generally, one liter of water per sampling location is a sufficient amount. If organic analysis is also required, five liters of water per location should be collected in glass bottles. Water collected in the field for laboratory analysis should be kept on ice (4° C [39° F]) during transport from the site and should reach the lab within 24 hours of collection.

2.2.3.3 Interpretation of water quality data for wetland functions

The following paragraphs can be used to relate particular wetland functions to water quality data obtained during the assessment. Functions are listed only if a strong relationship with water quality exists.

- Sediment/toxicant removal and nutrient removal/transformation: Pollutant removal and retention occur more readily in oxygenated waters and soils, because aerobic conditions allow biodegradation and chemical oxidation and prevent the release of some substances, such as phosphorous, which are bound to aerobic sediments (Horner and Raedeke 1989). Near-neutral or alkaline pH is best for pollutant trapping; pollutant removal and retention tend to decline as pH decreases to 5.5 or 6.0, depending on the contaminant. The difference in conductivity at a wetland's inlet and outlet can give a general indication of the amount of soluble contaminant retention (Adamus *et al.* 1987; Horner and Raedeke 1989). This function is especially important in areas where several potential nonpoint or point sources of sediment or toxicants are identified.

- Biological diversity and abundance: The ability of a wetland to perform this function is positively correlated to water quality. Certain conditions such as excess salt and potential sources of toxic material can limit a site's ability to provide habitat for birds and mammals. Low amounts of dissolved solids or the presence of potential toxicants restrict aquatic life (Adamus *et al.* 1987). In general, temperatures below 20° C (68° F) encourage invertebrate diversity and unicellular diatoms among phytoplankton. Green algae become dominant as temperature rises, and very high temperatures [greater than 30° C (86° F)] promote blue-green algae and reduce invertebrate diversity (Horner and Raedeke 1989).

Table 2-2. Ranges of water chemistry results for various wetland communities in Illinois (Simon and Cahill 1996) including number of wetland locations and the total number of samples for each community. General Use Water Quality Standards are also included (IEPA 1995).

	Natural Marshes	Natural Swamps	Restored or Created Marsh/Ponds	Natural Fens	Northern Flatwood Forests	General Use Water Quality Standards (*)
Number of Locations	8	3	6	2	1	
Number of Samples	24	14	14	13	12	
Total Dissolved Carbon	37.3 - 265.6	27.2 - 60.1	39.2 - 156.6	73.9 - 130.7	75.3 - 164.1	
Dissolved Organic Carbon	14.9 - 75.2	13.4 - 27.1	14.2 - 80.5	14.2 - 30.7	46.4 - 85.7	
Total Nitrogen	0.38 -9.06	0.50 - 3.9	0.68 - 5.34	0.05 - 8.74	0.48 - 2.12	
Total Kjeldahl Nitrogen	0.01 - 8.91	0.22 - 3.82	0.36 - 5.34	0.05 - 8.74	0.48 - 2.12	
Ammonia	0.01 - 3.18	0.06 - 0.81	0.01 - 0.33	0.01 - 2.17	0.01 - 0.10	1.5
Nitrate	0.07 -7.29	0.05 -0.25	0.06 - 0.58	0.05 - 0.22	0.05 - 0.15	
Total Phosphorus	0.02 - 2.20	0.05 - 0.55	0.01 - 1.29	0.02 - 1.55	0.01 - 0.20	
Sulfate	4.5 -129.0	0.65 - 22.8	0.3 - 135.0	5.8 - 52.7	3.3 - 319.0	500
Fluoride	<0.01 - 0.13	<0.01 - 0.07	<0.01 - 0.17	<0.01 - 0.29	<0.01 - 0.12	1.4
Chloride	0.8 -117.0	0.5 - 9.9	0.8 - 129.0	21.8 -76.6	1.8 -173.0	500
Bromide	<0.01 - 0.13	<0.01 - 0.22	<0.01 - 0.07	0.04 - 0.11	<0.01 - 0.10	
Total Alkalinity	8 - 815	20 - 176	38 - 311	232 - 421	46 - 314	
pH	6.0 - 9.5	6.2 - 8.7	6.8 - 8.7	7.5 - 8.6	7.0 - 7.8	6.5 - 9.0
Conductivity	89 - 1236	43 - 339	85 - 989	629 - 748	164 - 867	
Dissolved Oxygen						5.0^
Total Dissolved Solids						1000^
Aluminum	<0.02 - 0.15	0.02 - 0.05	<0.02 - 0.07	<0.02 - 0.17	<0.02 - 0.10	
Arsenic	<0.1	<0.1	<0.1	<0.1	<0.1	0.36
Boron	<0.02 - 0.11	<0.02 - 0.08	<0.02 - 0.06	<0.02 - 0.10	<0.02 - 0.06	1.0
Barium	0.01 - 0.12	0.03 - 0.10	0.01 - 0.07	0.04 - 0.21	0.01 - 0.05	5.0
Calcium	9.7 - 179.0	5.4 - 45.1	9.8 - 108.0	56 - 109	12.9 - 130.0	
Cadmium	<0.02 - 0.03	<0.02	<0.02	<0.02	<0.02	0.05
Chromium	<0.01	<0.01	<0.01	<0.01	<0.01	4.0
Copper	<0.01	<0.01 - 0.03	<0.01 - 0.01	<0.01	<0.01	1.0
Iron	0.02 - 3.58	0.01 - 2.61	0.02 - 0.45	0.01 - 0.21	0.05 - 0.45	1.0
Potassium	<1 - 8	<1 - 2	1 - 8	1 - 3	2 - 6	
Magnesium	2.2 - 83.0	1.4 - 16.7	4.3 - 51.7	37.4 - 46.3	5.9 - 72.0	
Manganese	0.01 - 4.85	0.01 - 4.3	0.01 - 0.72	0.01 - 0.57	0.01 - 0.10	1.0
Sodium	1.5 - 67.2	0.8 - 11.0	0.10 - 40.7	11.9 - 29.5	1.2 - 99.3	
Nickel	<0.03	<0.03	<0.03	<0.03	<0.03	1.0
Lead	<0.04	<0.04 - 0.07	<0.04	<0.04 - 0.04	<0.04	0.1
Mercury						0.5^
Selenium	<0.2	<0.2	<0.2	<0.2	<0.2	1.0
Silver						5^
Silicon	0.4 - 27.6	1.5 - 5.7	0.04 - 5.89	5.9 - 10.8	1.7 - 7.0	
Strontium	0.03 - 0.69	0.03 - 0.07	0.02 - 0.16	0.08 - 0.30	0.02 - 1.21	
Zinc	<0.01 - 0.02	<0.01 - 0.06	<0.01 - 0.02	<0.01 - 0.02	<0.01	1.0

Note: All values in mg/l except pH and µS for conductivity. All metals data are for the soluble fraction.
* State of Illinois Rules and Regulations, Title 35 of Environmental Protection, Section 302.201 - 302.212
^ Listed in General Use Water Quality Standards but not analyzed in this study

Aquatic production and species richness are favored by near neutral and slightly alkaline pH (5.6 to 8.6). This parameter also affects other water chemistry constituents such as nutrients and metals. For example, metals are usually more soluble and consequently more available to organisms when pH is acidic rather than basic (Horner and Raedeke 1989).

2.2.4 Vegetation

Vegetation assessment can provide important information for several purposes in the site assessment process. Assessing potential planned wetland sites is necessary to verify information obtained in the preliminary site characterization (Chapter 1, Section 1.5.3.3) and to determine the probability of establishment of beneficial wetland plants or exotic (non-native or nuisance) plants. The information obtained from existing natural wetlands can be used in the design phase to help choose appropriate plant species for a planned wetland. A search for threatened and endangered species also may be important when evaluating potential planned wetland sites and existing wetlands. Refer to Appendix H for a list of field guides. Vegetation assessment tasks are divided into two categories.

Level 1 vegetation assessment:

- Employs qualitative methods to describe general characteristics and features of plant communities.
- Is used when the vegetation can be easily described, *e.g.*, a low-diversity cattail marsh.
- Is designed for a user who has basic plant identification skills.

Level 2 vegetation assessment:

- Employs both qualitative and quantitative methods to provide more detailed plant community descriptions.
- Is useful when specific information for planned wetland design or baseline (preconstruction) characterization of a potential restored wetland site is needed.
- Requires greater botanical and/or statistical knowledge.

2.2.4.1 Level 1 vegetation assessment

The tasks described below include vegetation cover type mapping, compilation of species lists and assignment of abundance values, determination of dominants, and determination of percent predominance of hydrophytic vegetation. Depending on the purpose of the assessment, one or any combination of these methods may be appropriate.

Vegetation cover type mapping

Vegetation cover type mapping is the naming and delineating of biological communities within a project site. It is usually completed at a wetland site that will be adversely impacted to determine the plant communities present, if future plans include establishing similar communities elsewhere. Cover type mapping may also be conducted at a planned wetland site before restoration efforts begin. The map provides the wetland manager with a general description of the entire site and the areas and types of plant communities present.

Cover type mapping can be completed at a large scale, without a site visit, by using recent aerial photographs. For example, agricultural land, forest, shrubland, standing water, and streams can be easily discerned from aerial photographs. Mapping at this scale is part of the preliminary characterization for selecting potential planned wetland sites (Chapter 1, Section 1.5.3.3, "Vegetation characterization"). Appendix C, "Resource Materials and Sources," contains information about how to obtain aerial photographs.

A site visit is usually necessary to identify and more precisely define the boundaries of various forest communities and herbaceous wetland types. Mapping detail depends in part on the scale and quality of the aerial photograph. Map scale should range from 1:1200 [1 cm = 12 m (1 in = 100 ft)] to 1:4800 [1 cm = 48 m (1 in = 400 ft)]. In addition, each project may require a different level of detail. For example, project goals may require that a certain percentage of a specific herbaceous wetland type (*e.g.*, cattail marsh or sedge meadow) be established at the planned wetland. The only way to assess how much of this specific habitat type is present is to map cover types at the appropriate level of detail.

Biological communities are classified based on vegetation strata (layers represented by trees, saplings, shrubs, herbaceous plants, and woody vines), wetness regime (dry, mesic, wet), location (within a floodplain, along a ridge), and plant species composition. General knowledge of dominant plants is adequate to characterize the vegetation of each community. Determination of dominants is discussed later in this section. Vegetation cover types are listed in Appendix E. Wetland managers can develop additional cover type descriptions as needed for specific situations. Cover type mapping should be conducted during the growing season. Mapping can be done in the winter, but some strata, especially herbaceous plants, may be difficult to describe outside the growing season.

Compilation of species lists and assignment of abundance values

If a staff person proficient at identifying plant species at the assessment site is available, then a species list (as complete as possible) can be compiled for the site. Separate lists can be compiled for each plant community or vegetation cover type within the project area, or species found in all communities at the site can be grouped. Each species on the list is assigned an abundance value, which is an estimate of the plant's presence

throughout the site. In practice, the person conducting the assessment must survey the entire site, noting the overall presence of each species and deciding on an abundance value for the site as a whole. Abundance ratings are defined as follows (White 1978). The acronym DAFOR summarizes ranking and can help users recall the ranking order (Goldsmith 1991).

- (D) Dominant or very abundant nearly to the exclusion of other species - 5
- (A) Abundant or very frequently observed - 4
- (F) Frequently or commonly observed - 3
- (O) Occasional or infrequently observed - 2
- (R) Rare or very few individuals observed - 1

This method may be appropriate for a site where only a simple estimate of the abundance of different plant species at the site is required. Because it is an estimate and the categories are relatively broad, it is not appropriate where more detailed assessments are needed.

Determination of dominant vegetation

After biological communities within the project area have been delineated, the dominant plant species of each community can be determined. A plant species is considered dominant if through abundance or size, it exerts a controlling influence on neighboring species. This influence may occur as a result of shading, or water or nutrient allocation.

A procedure for determining dominant vegetation at a wetland site and useful for a general assessment of dominance is included in the "routine on-site wetland determination method" used in the jurisdictional wetland delineation procedure described in the *Corps of Engineers Wetland Delineation Manual* (Environmental Laboratory 1987). The method is further explained in the *Federal Manual for Identifying and Delineating Jurisdictional Wetlands* (Federal Interagency Committee for Wetland Delineation 1989). This method is used to determine species dominance for each stratum present in the plant community and relies on estimates of areal canopy coverage for individual plant species. Areal canopy coverage is an estimate of the vertical projection of the crown or shoot areas of a species to the ground surface expressed as a fraction or percent of a reference area (Mueller-Dombois and Ellenberg 1974). Only gross estimates of coverage are defined using this method. Assessment should be conducted during the growing season because vegetation of all strata, including herbaceous, must be assessed.

The steps to determine dominant vegetation are:

1. Examine the entire project area and identify plant communities and their boundaries. Mark these areas on a map or aerial photograph.
2. Select observation points that are in representative areas of each plant community.
3. Determine which strata are represented in each plant community. Strata are represented by trees, saplings, shrubs, herbaceous plants, and woody vines.
4. Determine dominant species in each stratum for each plant community. Common species of each stratum and their respective coverages are listed. These species are ranked in decreasing order and cumulatively totaled. When the total immediately exceeds 50% percent of the total dominance measure for that stratum, those species are determined to be dominant. Any additional plant species composing 20% or more of the total dominance measure for the stratum are included as dominants. Plant species in poorly represented strata need a minimum of 5% areal coverage to be considered dominants in the plant community.

Determination of percent predominance of hydrophytic vegetation

The percentage of dominant plants considered hydrophytic (wetland plants) often must be determined for potential planned wetland sites and for wetland communities within the project area. All vascular plant species in the United States have been assigned an indicator status rating, based on the likelihood that the plant would be found in a wetland community. The indicator status for each plant is published in the *National List of Plant Species that Occur in Wetlands: Illinois* (Reed 1988). Indicator categories of plant species are as follows:

- Obligate (OBL) - Occurs almost always (estimated probability >99%) under natural conditions in wetlands.

- Facultative wetland (FACW) - Usually occurs in wetlands (estimated probability 66-99%), but occasionally found in nonwetlands.

- Facultative (FAC) - Equally likely to occur in wetlands or nonwetlands (estimated probability 34-66%).

- Facultative upland (FACU) - Usually occurs in nonwetlands (estimated probability 67-99%), but occasionally found in wetlands (estimated probability 1-33%).

- Upland (UPL) - Occurs almost always (estimated probability >99%) under natural conditions in nonwetlands.

The method is applied after compiling the list of dominant plants, explained above. Each dominant plant is assigned its indicator status. Any plant rated facultative or wetter, *i.e.*, FAC, FACW, and OBL, is considered hydrophytic. A predominance of hydrophytic vegetation in the plant community exists if more than 50% of the dominants present are hydrophytic.

Determining if hydrophytic vegetation is present is one part of the procedure for jurisdictional wetland determination and delineation (Environmental Laboratory 1987). In a wetland determination, site soils and hydrology are also assessed. Characteristics of the site's vegetation, soils, and hydrology must meet wetland criteria for the site to be considered a wetland.

2.2.4.2 Level 2 vegetation assessment

The three approaches described in the Level 2 vegetation assessment are quantitative sampling, the Illinois Natural Area Inventory natural quality grading, and the floristic quality assessment. Quantitative sampling provides the most detailed information, while the natural quality grading and the floristic quality assessment are qualitative methods. In addition, an assessment of rare or exotic species may be necessary. Wetland managers may wish to conduct one or more of these techniques. The use of these methods during the monitoring phase of a project is described in Chapter 5, Section 5.5.4.2, "Level 2 vegetation monitoring."

Quantitative sampling

Quantification of the vegetation found within a natural community results in a detailed description of the site, but can be a time-consuming task. Quantitative vegetation sampling conducted within a subset area of the site can provide a useful characterization of the site in a fraction of the time. Vegetation sampling at an existing wetland or potential planned wetland site is usually conducted to obtain information about species richness, frequency, density, and dominance (cover) within the plant communities.

Sampling criteria and design are goal-driven. For example, sampling units can be established based on individual plant community characteristics, such as vegetation cover types (refer to Appendix E and Section 2.2.4.1, "Level 1 vegetation assessment"), so that an upland forest is sampled separately from an adjoining floodplain forest. Areas may be further subdivided if distinct differences in forest stand age, quality, or species composition exist. Alternatively, the design may allow sampling across community boundaries.

Sampling methods for each vegetative stratum (trees, saplings, shrubs, herbaceous plants, and woody vines) are described in Appendix I, "Quantitative vegetation sampling." The methods described in Appendix I are not optimal for all situations. The wetland manager is encouraged to explore other sampling methods in order to determine the most suitable for specific projects. Many wetland soils are easily disturbed and susceptible to compaction by foot traffic, especially if paths for sampling transects are traveled regularly. Areas that are especially susceptible to disturbance include newly-established wetlands with young and unstable soils and high-quality wetlands such as fens, seeps, and bogs, which remain saturated nearly all year. To lessen disturbance in wetland areas, sampling is best done during a dry phase of the growing season, if the representative vegetation is also present at this time. Additional references on quantitative sampling in wetlands are Magee *et al.* (1993), Stevens and Vanbianchi (1993), Horner and Raedeke (1989), and Kentula *et al.*(1992).

Illinois Natural Areas Inventory natural quality grading

Natural quality grading can be used to describe natural communities, as a basis for comparison among sites and within sites, and as a guide for project goals. The Illinois Natural Areas Inventory defines natural quality as a "measure of the evidence of disturbance to a natural community" (White 1978). The highest quality natural communities are those with the least amount of disturbance. Using a system of letter grades (A through E, with A being the least disturbed), features of a site such as the community's natural diversity, species composition, vegetation structure (often influenced by disturbance), grazing pressure, and age of forest stand can be evaluated. Common disturbances are livestock and wildlife (*e.g.,* deer and geese) grazing, graded or filled soils, timber harvest, exotic species pressures, altered moisture levels, residential and commercial development, and fire suppression. Appendix J, "Illinois Natural Areas Inventory Natural Quality Grading," explains how to determine natural quality grades, evaluate grazing pressure, and estimate the age of forest stands.

Floristic quality assessment

The floristic quality assessment (FQA) described by Swink and Wilhelm (1994) and further developed by Taft *et al.* (1996) are revisions of the Natural Areas Rating Index first published in *Plants of the Chicago Region* (Swink and Wilhelm 1979). This floristic assessment was developed in response to a need to evaluate and rank the natural quality of open lands in the Chicago region, and is now used in some parts of the state to identify high-quality natural areas and to compare floristic quality among sites. In this context, natural areas are those where the plant communities reflect perceived native, presettlement conditions, and may or may not be statewide significant natural areas according to Illinois Natural Areas Inventory standards. The FQA may be required by some regulatory agencies for wetland compensation projects.
Each taxon in the Illinois flora has been assigned a coefficient

of conservatism. Individual conservatism coefficients reflect each species' affinity for a natural area, *i.e.*, the coefficients are ranks of species behavior and represent the committee's (Taft *et al.* 1996) confidence level for a taxon's correspondence to anthropogenic disturbances. When a complete species list is assembled for a wetland site, the overall average conservatism coefficient and a site floristic quality index (FQI) can be calculated. These values provide measures of site floristic quality. For a more detailed explanation of how to apply the method and some of its limitations, see Appendix K, "Floristic Quality Assessment."

Rare species

A rare plant species, including species listed as threatened or endangered in the state of Illinois or at the federal level, occasionally may occur within a project site. During the site assessment phase, determining the location and size of the rare plant population may be adequate, a task that could be completed in a single site visit. The assessment can be conducted at an existing site, so that habitat goals can be developed for the planned wetland established as compensation for impacts, or at the potential planned wetland site, primarily if the site is suitable for restoration. Data gathered during the assessment of a potential restoration site can be used as a baseline for comparison with information gathered in the subsequent monitoring phase (see Chapter 5, Section 5.5.4.2, "Level 2 vegetation monitoring").

Rare species, by their nature, are difficult to assess by conventional quantitative sampling methods. Conventional methods would be apt to miss the population entirely; therefore, methods that directly target the species are used. The amount of effort spent sampling a rare plant population depends on project goals and objectives. If the project goal is to determine if the rare species is present at the impacted site, a thorough meander search in the appropriate season would be adequate. If the project goal is to maintain an intact population at a site after the planned (most likely restored) wetland is established, and continued monitoring is planned, the assessment will be used as baseline data. The sampling strategy is tailored to the proposed monitoring program to allow for meaningful comparisons. Detailed procedures for assessing rare species are found in Appendix L.

If rare species are located or introduced into planned wetlands, the occurrence or introduction should be reported to the Endangered Species Protection Board (Appendix B, "Natural Resources Agencies").

Exotic species

Exotic species are plants that are not native to the flora of the region in which they are found. They may have been accidentally or purposefully introduced into North America from Asia or Europe (Illinois Nature Preserves Commission 1990). Exotic plant species may be located at an existing wetland or the potential planned wetland site. The presence of exotics at a site that will be impacted has little importance, but exotics occurring at the planned wetland site or in the adjacent buffer, especially at a restored wetland, may have lasting effects on the future floristic and wildlife habitat quality of the site. Assessing their presence provides baseline information for later monitoring efforts. Monitoring of exotic species at a planned wetland site is explained in Chapter 5 (Section 5.5.4.2, "Level 2 vegetation monitoring").

Exotic species are similar to rare species in that they may grow and spread from patchy populations. Therefore methods and guidelines for assessing exotic species are similar to those used to assess rare species. Conventional sampling methods may miss a population entirely, and methods that directly target the species must be used. Methods are discussed in Appendix M, "Exotic Species Assessment and Monitoring."

2.2.4.3 Interpretation of vegetation data for wetland functions

The following paragraphs can be used to relate particular wetland functions to vegetation data obtained during the assessment. Functions are listed only if a strong relationship with vegetation exists.

- Flood flow alteration: Vegetation acts to disperse the energy water flow through a system. The erosive forces of precipitation and overland flow are reduced through interaction with vegetation (Carter *et al.* 1979). Densely vegetated wetlands with vegetation more than 1.8 m (6 ft) tall are able to control flood flows more than those dominated by open water or low-growing vegetation. Included in this category are forested or scrub-shrub wetlands where the percent coverage of tall vegetation is greater than 50, with percentages of more than 70 being highly desirable (Roth *et al.* 1993). The presence of buffers surrounding a wetland can also help to moderate otherwise severe water level fluctuations because vegetation can slow the flow of runoff, allowing water to percolate into the litter and soil (Castelle *et al.* 1992).

- Sediment stabilization: Vegetation protects shoreline banks from erosion by reducing wave energy before it reaches the bank face, and stabilizing and reducing the rate of shoreline and bank erosion (Watts and Watts 1990). Rhizomatous plant species and those that form a root mat increase the durability of the sediment-root matrix and overall bank stability (Thorne 1990). The vegetation must also have a growth form, density, and aerial coverage suitable to reduce wind, wave, and current action (Sather and Smith 1984). Species that are more effective at dissipating wave energy are those whose average plant height is equal to or taller than average high water level (Knutson *et*

by other natural communities, wildlife inhabiting the adjacent areas could also use the wetland. In addition, natural communities provide a buffer against human disturbance of the wetland. Therefore, wetlands where the majority of the surrounding land (>50%) consists of natural communities (*e.g.*, upland forest, successional fields) are given the highest rating. If the majority of the land surrounding a wetland is agricultural, the overall wildlife value is lower. Agricultural land does not provide a habitat diversity comparable to that of natural communities, but it does provide a wetland with a buffer against intense human activity. Waste grain can be an important food resource for wetland species (*e.g.*, waterfowl or rodents). However, some agricultural practices may adversely affect a wetland's water quality. If the majority of the land surrounding a wetland is developed (urban or industrial), human activities could prevent disturbance-sensitive species from inhabiting the wetland and may affect the wetland's water quality. Also, relatively few wildlife species in adjacent areas would utilize the wetland. Surrounding land use can be assessed by visual inspection at the site.

Dispersal corridors
The presence of dispersal corridors linking the wetland to other areas of natural habitat, especially other wetlands, increases the likelihood of the wetland being used by wildlife. Dispersal corridors include streams, drainage ditches, vegetated fencerows, and railroad rights-of-way. The presence of corridors can often be determined from USGS topographic maps, but should be verified by a reconnaissance of the area surrounding the wetland being assessed.

Food resources
A wetland that provides a diversity of food resources can support a greater abundance and diversity of wildlife. Point values are assigned to types of plants or animals observed in a wetland based on their relative importance as food for wildlife. Plant groups included in the assessment are those commonly found in or adjacent to Illinois wetlands. The point values given on the field form are based on information in Martin *et al.* (1951) and Anderson (1959). Information on the food habits of individual wildlife species is sometimes scarce and the importance of specific food items can vary greatly with region, season, utilization of agricultural crops, and fluctuations in seed production. Therefore, the point system is designed so that points awarded for individual plant groups have a small effect on the overall score for a wetland. Food derived from animal sources can compose a high percentage of the total points for a wetland because of the importance of animal foods in the diet of some migratory waterfowl and wading birds.

Hydroperiod
Wetlands that contain permanent standing water provide the most opportunities for wildlife use (breeding, foraging, migration stop-overs) and are given the highest rating. Wetlands that contain standing water during part of the spring and summer may provide breeding sites for some wetland-dependent species as well as foraging sites. Wetlands with no standing water can provide wildlife cover (especially valuable if surrounding areas are relatively devoid of cover), but will not be used for breeding by many wetland-dependent species and will be less suitable for foraging. Hydroperiod can be estimated by observing indicators of the presence of water (see Section 2.2.2.2, "Level 2 hydrogeology assessment").

Percent open water
The percentage of open water that provides optimal habitat varies among species. Typically, wetlands with 50% open water support the highest diversity and abundance of waterfowl and other wetland-dependent birds. As the percentage of open water increases, the amount of vegetation decreases, limiting cover. The highest rating is given to wetlands that have from 20 to 50% open water. In general, wetlands that are devoid of vegetative cover or completely covered with vegetation offer limited value to many kinds of wildlife. The percentage of open water can be determined by visual estimation and verified by referring to an aerial photograph of the site.

Water/Vegetation interspersion
The diversity and abundance of wetland-dependent birds is higher in wetlands with a high level of interspersion of water and vegetation. This situation provides a close association among food, protective cover, and nest sites. The greatest amount of interspersion occurs where numerous patches of vegetation are scattered throughout a wetland or where the edge of the vegetative cover is highly irregular. Interspersion can be assessed by visual inspection and verified by referring to an aerial photograph of the site. Examples of different degrees of interspersion are illustrated on the field form.

Special habitat features
Certain physical features in a wetland may increase the likelihood of wildlife using the wetland by providing cover, loafing sites, or nest sites. Examples are snags, brush piles, logs, muskrat houses, and boulders. Wetlands where such features are common are given the highest rating. Their presence can be determined by visual inspection.

Wildlife observations
During the course of assessing a wetland any observations of wildlife species should be noted. An animal may be observed directly, its vocalizations heard, or its sign (*e.g.* tracks, scat)

detected. Field guides and audiotapes that are useful for confirming the identity of species that occur in Illinois are listed in Appendix H. Presence of a threatened or endangered species is interpreted as an indication that the wetland has very high value for wildlife in general. A list of Illinois threatened and endangered species that use wetlands is provided with the field form. Range maps for endangered and threatened species in Herkert (1992) can be consulted to determine which species could potentially occur in the wetland being assessed.

2.2.5.2 Level 2 wildlife assessment

Level 2 of the wildlife assessment involves qualitative or quantitative surveys of a wetland's fauna. Depending on the information needed for a given site, inventories or censuses can be conducted for the vertebrate fauna as a whole, particular groups of vertebrates (*e.g.*, frogs, birds, or small mammals), or one or more specific threatened or endangered species. An inventory produces a list of species present at a site; a census is the collection of quantitative data that can be used to calculate relative abundance or population densities. Techniques used depend on the taxonomic group being studied; some require specialized equipment such as traps or drift fences, and can be labor intensive and/or time consuming. The use of methods that involve capturing and handling animals may require personnel conducting the assessment to obtain a scientific permit from the Illinois DNR Division of Wildlife Resources (see Appendix B, "Natural Resources Agencies").

Amphibians and reptiles

Standard methods for conducting amphibian surveys are described in Heyer *et al.* (1994). Inventories of amphibian species are frequently performed by conducting visual searches of an area; searches can be random and opportunistic or systematic. Frogs and toads can be identified and censused by listening to the calls of breeding males. See Appendix H, "Field Guides," for information on obtaining audiotapes of frog and toad calls. Amphibians can be captured in dip nets, seines, or pitfall traps associated with drift fences. Appendix C, "Resource Materials and Sources," lists sources for this equipment.

Some of the techniques for amphibian surveys (Heyer *et al.* 1994) can also be used for reptiles. Methods for conducting inventories and censuses of reptiles are described in Cooperrider *et al.* (1986). Visual searches are commonly used for inventories of reptile species; searches should be conducted during both the day and night to record diurnal and nocturnal species. Methods for capturing reptiles include pitfall traps (either in arrays or associated with drift fences), funnel traps, and snares. Because reptiles differ greatly in morphology and behavior, a combination of methods are required to sample the entire reptile assemblage in an area.

Birds

Methods for bird surveys are described in Ralph and Scott (1981) and in Cooperrider *et al.* (1986), which includes specific chapters on marsh and shorebirds, waterfowl, and colonial waterbirds. Birds are typically inventoried by recording all species seen or heard in an area, usually within two to three hours of sunrise. Commonly used census methods are point counts, spot mapping, and strip transect counts. The point count method is the most generally applicable and involves recording all individuals of each species seen or heard at a census point during a specified period of time. Specialized techniques include aerial surveys for large raptors, waterfowl, or nest counts at heron rookeries, and using tape-recorded calls for owls at night. Some wetland birds, such as rails, can be very secretive and the chance of detecting their presence is increased by use of the tape-playback technique to elicit calls (Connors 1986). A different assemblage of bird species will occupy a wetland during the breeding season, spring and autumn migration periods, and winter. Therefore, inventories or censuses are conducted during each season unless only breeding species are of interest.

Mammals

Mammals differ greatly in size and behavior and a combination of methods are needed to inventory the entire mammalian assemblage in an area. Methods for conducting mammal surveys are described in Davis (1982) and Cooperrider e*t al.* (1986). Small mammals (*i.e.*, some rodents and insectivores) can be inventoried and censused with snap traps, pitfall traps, or live traps. Snap traps or live traps can be placed in lines or grids; pitfalls can be arranged in grids or associated with drift fences. Larger species of mammals (*e.g.*, lagomorphs, carnivores, and ungulates) are usually detected by direct observation or the presence of sign rather than by trapping. Aerial surveys, roadside counts, counts of sign, flushing counts, and scent-station surveys can be used to estimate the relative abundance of larger mammals. Specialized techniques needed for bat inventories are described in Cross (1986) and Kunz (1988). The presence of bats can be determined by visual observation, supplemented with the use of a bat detector. Species identification usually requires capturing animals, and bats are very difficult to census.

2.2.5.3 Interpretation of wildlife data for wetland functions

The following paragraphs can be used to relate particular wetland functions to wildlife data obtained during the assessment. Functions that are listed have a strong relationship with wildlife.

- Biological diversity and abundance: The presence of a variety of wildlife increases a wetland's biological diversity and

abundance. Wildlife attracts other wildlife, *e.g.*, invertebrates, smaller birds, and mammals are a food source for larger animals. Also, wildlife that travel between wetlands further contribute to a wetland's vegetative diversity by transporting plant propagules on their bodies or in their feces.

- Recreation and aesthetics: The presence of animals such as waterfowl, muskrat, and beaver, attract hunters and trappers to a wetland. Both game and nongame species lure photographers and bird watchers.

- Natural heritage: Wildlife may fulfill this function when state or federal endangered or threatened species are present or if the site provides critical habitat for them. Although endangered species habitat is related to the biological diversity function, society has placed additional significance on endangered and threatened species (Bartoldus *et al.* 1994).

Chapter 3 Designing Restored and Created Wetlands—Summary

This chapter discusses certain ecological considerations and requirements of planned wetland design.

- General guidelines for wetland design focus on characteristics of natural wetlands, such as shallow water depths, gradual slopes, and native plant communities.
- Design guidelines for particular wetland functions can be followed to promote achievement of project goals and objectives.
- Design elements for a planned wetland primarily address how to maintain the desired wetland hydroperiod. This may involve restoring hydrology by removing tile lines or ditches, building dikes, or installing water control structures. Excavation and lining of the basin are also discussed.
- Landscape plans present design information as written text and illustrations.

The cases below describe situations in which a wetland designer or manager would use this chapter. Guidelines and procedures in the first four sections of the chapter apply to all projects. The remaining chapter sections can be used in some, but not all, situations. For the two cases described below, we suggest the appropriate section at which to begin.

- **Case 1** The project site is a former wetland that has been tile drained but the original wetland basin is intact and located low in the landscape; the project goal is to restore biological diversity and abundance:
Section 3.5.1, "Drainage mechanism removal," should be followed to locate and block or remove the tile system. Additional design elements will not be necessary. Only procedures for applicable components of the landscape plan will need to developed.

- **Case 2** The projet site borders an entrenched stream; the project goals are sediment removal and nutrient removal/transformation:
Follow the design procedures beginning with Section 3.5.2, "Hydraulic requirements," through the end of the chapter.

Chapter 3
Designing Restored and Created Wetlands

3.1 Introduction

This chapter offers guidance and procedures for the special considerations and requirements of ecological wetland design for both restoration and creation projects. Wetland design is driven by project goals and objectives, including the functions, community type, and size of the planned wetland (Chapter 1, "Planning Restored and Created Wetlands"). It involves the selection and arrangement of materials (*e.g.*, soils and plants) in a landscape that best promote achievement of project goals. General guidelines and design features for particular wetland functions are discussed. Suggestions for preparing a landscape plan are provided.

The design chapter is written especially for those who have some knowledge of design techniques but have less experience with wetland systems. Detailed design specifications are not presented, and completing this phase of the wetland project will probably require an engineer's assistance. Additional design information can be obtained from natural resources agencies (Appendix B) and other publications. Recommended companion materials to the *Guide* regarding design include *Engineering Field Handbook* Chapter 13, "Wetland Restoration, Enhancement, or Creation" (USDA-SCS 1992a) and *Techniques for Wildlife Habitat Management of Wetlands* (Payne 1992). Engineers may find resources such as *Design of Small Dams* (U.S. Department of Interior-Bureau of Reclamation 1987) useful. *Restoring Prairie Wetlands* (Galatowitsch and van der Valk 1994) and the *Minnesota Wetland Restoration Guide* (Wenzel 1992) are helpful for wetland restoration projects.

3.2 Guidelines

3.2.1 Preserving existing features
A priority in wetland design is to preserve as much of the existing landscape as is practical. Areas within the project site that contain significant populations of desirable native plants or animals should be fenced off and protected, because these are sources of propagules and individuals for dispersal into newly established areas (Figure 3-1). Impacts to the soils of a site should be minimized as much as possible. Too much activity by heavy machinery, even four-wheeled farm tractors, will compact the soil and destroy its structure. Soil structure must be maintained for optimum plant growth. If necessary, compacted soils can be amended and soil structure improved with additions of organic matter and sand (see Chapter 4, Section 4.5.1, "Soil amendments").

3.2.2 Salvage

Soil and plant propagules can be salvaged from another wetland for use in planned wetland projects. "Donor" soil should be taken only from wetlands that are slated for destruction in the near future and not from those that are protected or unthreatened. Salvaging soil is warranted in two cases: 1) when the donor soil contains a viable seed bank (a reserve of ungerminated, viable seeds within the soil); or 2) when the subsoil at a wetland creation site is too dense or clayey for plant growth (silty clay or heavier) (M. Kraus, Environmental Concern, Inc., pers. comm.). Applying topsoil has been shown to be effective in many situations (Clewell 1981; Dunn and Best 1984; Brown *et al.* 1985; Erwin and Best 1985; Erwin *et al.* 1985; Ross *et al.* 1985; Worthington and Helliwell 1987; Siegley *et al.* 1988).

3.2.3 Buffers

Restored and created wetlands are susceptible to disturbance and encroachment from surrounding land use. Vegetated buffers (sometimes called buffer strips or filter strips) around a wetland are an effective means to reduce or prevent impacts caused by soil erosion and severe water level fluctuations and can be incorporated into planned wetland design.

Typically, buffers are preserved or established adjacent to and upslope from a wetland. Aquatic areas contiguous with a wetland edge can also buffer adverse impacts (Castelle *et al.* 1992). One or a series of up-gradient settling basins may be necessary to filter pollutants from waters feeding into wetlands that have been restored or created to provide habitat for sensitive aquatic wildlife (USACE 1993). Further information can be found in Sidebar 3A, Buffer design.

3.2.4 Natural land form

The planned wetland should be designed to emulate the natural configuration of the wetland type being restored or created. For example, an amorphous configuration (Figure 3-2a) is suitable for wetland restoration and creation. A geometric configuration (Figure 3-2b) may be acceptable for a borrow-pit, but not for a wetland. In marshes and open water wetlands, a hemi-marsh configuration, *i.e.*, a 50:50 ratio of emergent vegetation to open water, promotes the greatest wildlife diversity and density (Kantrud *et al.* 1989).

Level to gentle slopes (less than 3%) are optimal for planned wetlands (Jones 1993; USACE 1993). Descriptions and maps in soil survey reports indicate that the topography of nearly all hydric soil units is level to gently sloping (0.5 to 2%). Most wetland plants will not grow on, and should not be specified for, areas with greater than 5% slope. Gentle slopes in the emergent zone provide a broad zone of water depths for emergent plant growth even where water fluctuations are large and unpredictable, whereas slopes of 3:1 or 6:1 allow only a narrow band of emergent vegetation to become established (Crabtree *et al.* 1992).

Sidebar 3A

Buffer design

Buffer design depends on several factors. Although no standard buffer widths have been established for wetlands in Illinois, the Northeastern Illinois Planning Commission has recommended buffer widths for northeastern Illinois streams. Generally, buffer widths (measured from the typical high water mark) should range from 15 to 61 m (50 to 200 ft) (Mariner and Mertz-Irwin 1991). In urban areas, where infrastructure is not permitted within 23 m (75 ft) of a stream's typical high water mark, a vegetated strip at least 7.6 m (25 ft) wide must buffer the stream (Mariner and Mertz-Irwin 1991). Another guideline based on slope and function suggests that, if water flows with a runoff velocity of 0.50 ft/s off a 5% slope of dense grass, a buffer 61 m (200 ft) wide is needed to trap 95% of the sediments carried in the water (IDNR no date). For comparison, in the New Jersey Pinelands region, recommended wetland buffer widths range from 15 to 91 m (50 to 300 ft). A minimum buffer width of 91 m (300 ft) is assigned to "special cases," for instance, if wetlands provide habitat for threatened or endangered species, if nearby development is mineral extraction or a related activity, or if the site is to be used for domestic wastewater treatment (Roman and Good 1986; Nilson and Diamond 1989).

Methods for establishing riparian buffers proposed by Welsch (1991) can also be applied to wetland buffers. In this design, the buffer consists of three zones. Zone 1 is a 4.5-m (15-ft) wide strip located at the top of the stream bank. Zone 2 begins at the edge of Zone 1 and extends out to a minimum width of 18 m (60 ft). Zone 3 is a strip at least 6 m (20 ft) wide adjacent to Zone 2. Native riparian tree and shrub species make up Zones 1 and 2, and dense grasses and forbs dominate Zone 3. For ellipsoid-shaped open water wetlands, the buffer is a uniformly wide strip between the wetland and the surrounding land, and the total buffer area should be at least one-fifth the drainage area of the wetland. Other ways to determine buffer width are based on soil hydrologic groups and soil capability classes of the buffer site, as described in county soil survey reports (Welsch 1991).

Buffer shape and vegetation type also contribute to buffer effectiveness for several functions. Narrow, rectangular buffers seem to effectively prevent nutrients from entering ground water (Haycock and Pinay 1993). Conversely, buffers that are round or in blocks are more useful for wildlife habitat (IDNR no date). In general, increasing the percentage of ground covered by vegetation decreases runoff velocity and, by trapping sediment, improves water quality (IDNR no date). Forested buffers are more efficient than grass buffers in reducing nitrate-nitrogen concentrations in shallow ground water, whereas grass buffers are more efficient at reducing phosphorus (Osborn and Kovacic 1992). For stream bank stabilization, the Northern Illinois Planning Commission recommends planting both native grasses and woody vegetation together when forested buffer strips are becoming established; or planting willow or other effective tree species, followed by a thinning and planting of grasses (Mariner and Mertz-Irwin 1991).

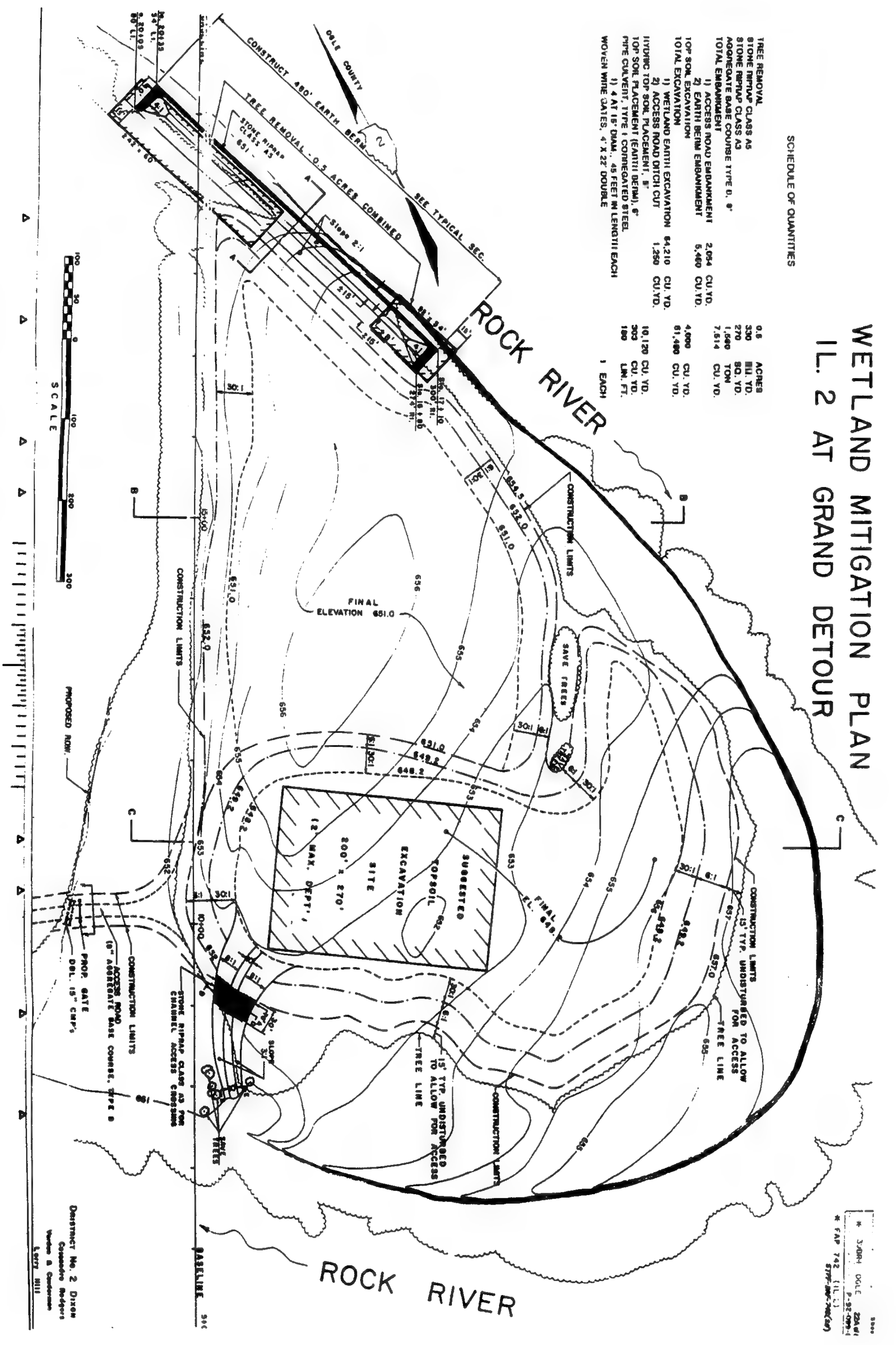

Figure 3-1. Example of a wetland mitigation plan. Note areas designated for protection of existing trees.

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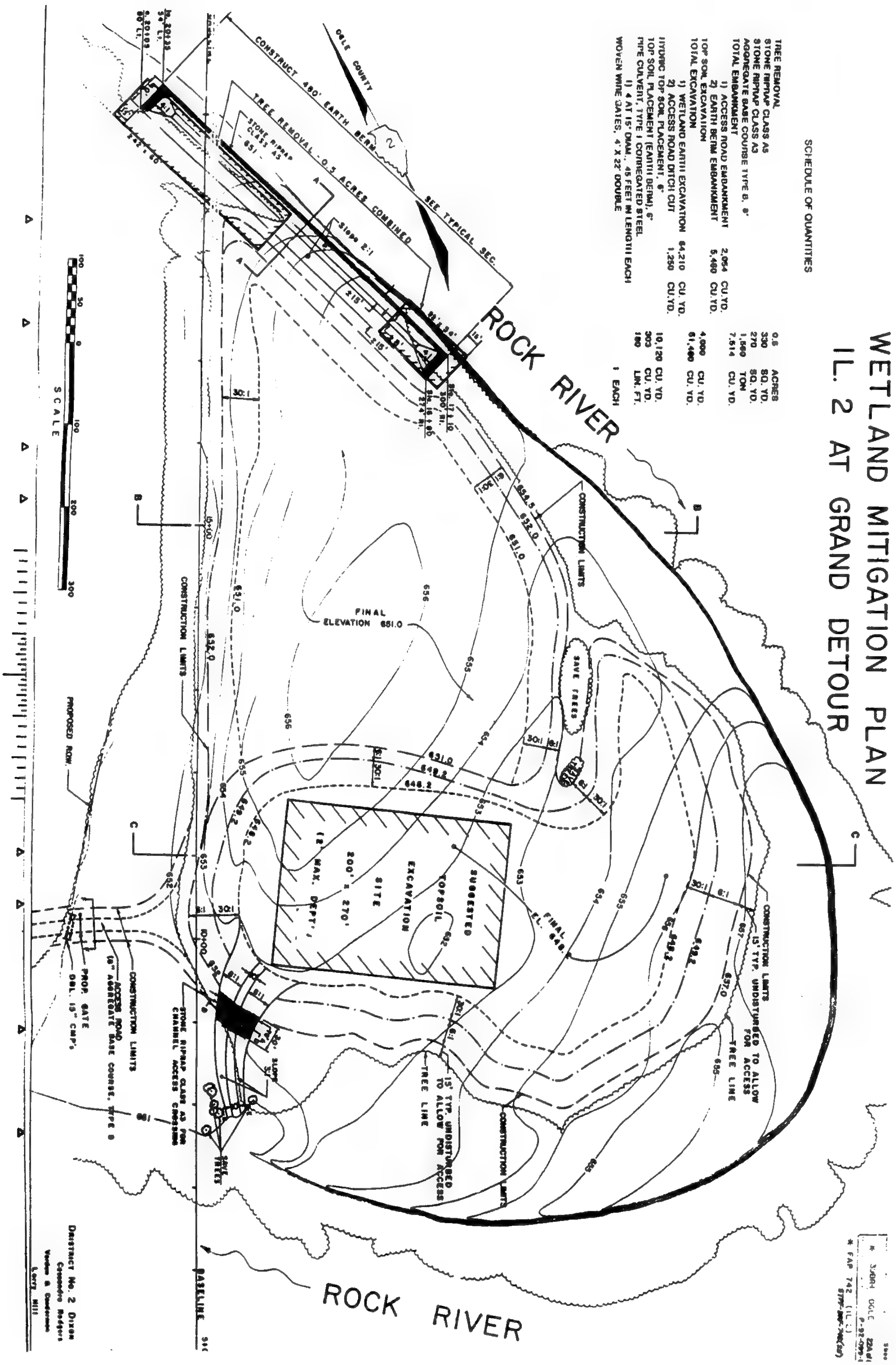

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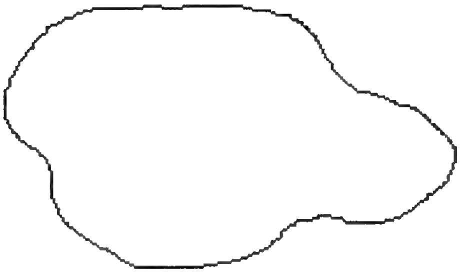


a.

b.

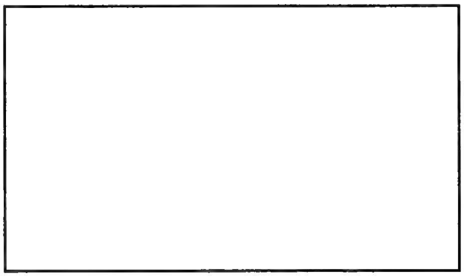


Figure 3-2. Possible wetland configurations: a) amorphous, b) geometric.

3.2.5 Water depth and hydrologic regime

Wetland water depth can be less than 1 cm (0.4 in) in emergent wetlands, or as much as 2 m (6.6 ft) in open water wetlands (Cowardin *et al.* 1979; Havera *et al.* 1994). For planned wetlands that will be seasonally or semi-permanently flooded, maximum water depth should not exceed 0.6 to 0.9 m (2 to 3 ft) (Jones 1993). In order to achieve irregular rather than uniform grades in an excavated wetland basin, plus and minus tolerances can be specified on grading plans, *e.g.*, 0.8 m ± 0.2 m (2.6 ft ± 0.6 ft) (Bickmore and Larard 1989). This allows a variety of plant species that are adapted to various water depths to become established throughout the wetland.

A number of different wetland hydrologic regimes may be incorporated into planned wetland design. Table 3-1 describes these regimes. As a rule of thumb, the minimum requirement for "dry end" wetland hydrology is saturation of the root zone for 12.5% of the growing season (note that areas that are wet for as little as 5% of the growing season are sometimes considered wetlands). According to information in regional county soil surveys, the central Illinois growing season lasts approximately 200 days. Therefore, wetland hydrology occurs where soil in the root zone is saturated for approximately 25 days. Soil must be saturated for approximately 22 and 27 days during the growing season in northern and southern Illinois, respectively.

3.2.6 Natural cycles

Planned wetlands can benefit from and account for natural cycles or disturbances (Mitsch and Cronk 1992). These cycles can be related to animal population dynamics and climatic changes. Annual precipitation patterns are particularly important. For example, periods of drawdown are required in wet floodplain forests so that seeds can germinate on the exposed mineral soil surface.

Another type of change in natural communities is succession, the replacement of one biological community by another over time. For example, a relatively open, scrub-shrub community may succeed to a closed canopy forested wetland as larger tree species colonize, grow, and reproduce. The wetland designer or manager must anticipate these types of changes in the overall design and sustainability of the planned wetland community. If certain wetland communities are to be maintained, measures such as water control or fire must be carried out to interrupt succession. Refer to Chapter 6, "Managing Wetlands," for a discussion of wetland management to achieve project goals.

3.2.7 Plant species selection

Hydrophytes, or plants adapted to life in wetlands, should always be utilized in wetland projects. *The National List of Plant Species That Occur in Wetlands: Illinois* (Reed 1988), lists those Illinois plants that are typically found in wetlands. Native plants or seeds that are grown in the region should be used whenever possible in planned wetlands. Specifically, regional ecotypes, *i.e.*, plants that occur naturally within 322 km (200 miles) of the project site, are better adapted to local environments than plants originating from regions with different soils and climates. Furthermore, native plants are an important part of our natural heritage, and their use is essential to projects emphasizing this function. Exotic, or non-native, plants can cause problems in adjacent natural areas and in the planned wetland by competing with natives for resources. See Appendix N, "Commercially Available Illinois Native Plant Species," for an extensive list of wetland plant species offered by Midwest nurseries.

Water depth and duration of inundation are the next factors to consider when selecting plants for a design (see Table 3-1). Some plants tolerate permanently flooded conditions, in water up to 2 m (6.6 ft) deep, while others tolerate semi-permanently flooded conditions in water as deep as 0.3 to 0.6 m (1 to 2 ft). Other plants are adapted to soil that is saturated for three weeks or more during the growing season and will not survive in 0.3 to 0.6 m (1 to 2 ft) of water for more than a few weeks. Guidebooks on wetland plants can be consulted to determine which plants are adapted to the hydrology of the planned wetland (Garbisch 1986; Payne 1992; Galatowitsch and van der Valk 1994). Refer to Appendix P, "Growth and Propagation Requirements of Selected Wetland Plant Species."

Table 3-1. Hydrologic regimes for freshwater wetlands [modified from Environmental Laboratory (1987); categories adapted from Clark and Benforado (1981)].

Hydrologic regime	Duration*	Comments
Permanently inundated	100%	Inundation defined as >2 m (6.6 ft) mean water depth
Semi-permanently to nearly permanently inundated or saturated	>75% - <100%	Inundation defined as <2 m (6.6 ft) mean water depth
Regularly inundated or saturated	>25% - 75%	
Seasonally inundated or saturated	>12.5% - 25%	
Irregularly inundated or saturated	≥5% - 12.5%	Many areas having these hydrologic characteristics are not wetlands
Intermittently or never inundated or saturated	<5%	Areas with these hydrologic characteristics are not wetlands

* Refers to duration of inundation and/or soil saturation during the growing season.

3.2.8 Plant species compatibility

Planting designs for planned wetlands can be patterned after species associations known in natural settings, because these associates are adapted to similar environmental conditions. Natural associates are grouped into larger units called plant communities. The *Directory of Illinois Nature Preserves* (McFall and Karnes 1995) gives locations (including the natural division) and descriptions of high quality natural communities. Appendix Q, "Illinois Wetland Nature Preserves," lists nature preserves that contain wetland communities. Other sources of information about plant species associations include nursery owners and the text *Plants of the Chicago Region* (Swink and Wilhelm 1994).

Observe and photograph plant associations and distributions at wetland nature preserves and use these to develop planting designs for planned wetlands. Be sure to select and study wetlands of the same type (*e.g.*, marsh, swamp, wet prairie) and in the same natural division (Figure 1-4) as those that will be restored or created at the project site. Also examine wetlands in the local area and note landscape position and elevations.

Generally, project designers specify a large number of species appropriate to the specific wetland community, even if diversity is not a stated project goal. High species diversity usually promotes wildlife diversity and use and increases the potential for overall project success. A diversity of species will be more resistant to herbivores and invasive species, and more resilient to disturbance (USAEWES 1993a).

3.3 Design for wetland function

Planned wetland project goals typically target one or more wetland functions, and therefore project design needs to focus on the desired functions. Wetland functions are defined in Chapter 1, Table 1-1. This section presents design recommendations for wetlands performing a particular function. Prerequisite to design is the opportunity to provide a function. Opportunity is heavily dependent on site selection. The following information is adapted from guidelines for design and site selection for wetland function written by Marble (1992).

3.3.1 Flood flow alteration

The best sites designed for this function have constricted outlets: less than 1/3 of the average width of the wetland or less than 1/3 of the cross sectional area of the inlet. To promote flood flow desynchronization, low gradients allow the water to move as sheet flow and come into contact with frictional surfaces, *e.g.*, substrate and vegetation.

Similarly, the potential to desynchronize flood flow increases as the ratio of vegetation to open water increases. Vegetation height equal to or greater than the water depth during floods promotes maximum resistance. Forested or shrub-scrub vegetation cover provides the best overall opportunity for providing this function.

3.3.2 Sediment stabilization

Any feature that boosts the frictional resistance to or slows the velocity of moving water increases a wetland's potential to stabilize shorelines of rivers and lakes. Wide, shallow slopes that dip gradually from the shoreline towards the center of the

wetland are important for this function. Vegetation on shorelines increases frictional resistance; persistent species (woody or emergent plants whose dried stems remain throughout the year) and those that penetrate the entire water column are most appropriate. Plants should be arranged in bands at least 9 m (30 ft) wide.

3.3.3 Sediment/toxicant removal

Decreasing the velocity of incoming water is a key factor in removing suspended sediments. Wetlands designed to remove sediments from surface water should have gentle gradients and a constricted outlet or no outlet at all. Shallow depths and dense plantings of persistent emergent vegetation will slow moving water and, in turn, allow sediments to settle.

3.3.4 Nutrient removal/transformation

Design concepts for nutrient removal/transformation are similar to those for sediment/toxicant removal (Section 3.3.3). For wetlands to perform either function, they must be fed by surface water that contains nutrients or sediments.

3.3.5 Production export

Wetland design can facilitate high plant productivity and subsequent distribution of nutrients. Fine-textured soils are usually more productive than sandy or coarse-textured soils. Planting designs should include a variety of plant forms, but emphasize aquatic bed (*e.g.*, pondweed [*Potamogeton* spp.], duckweed [*Lemna* spp.]) and emergent species. A variety of vegetation cover types ensures uninterrupted production export throughout the year. Select species that are high in annual primary productivity.

Landform designs should include undulating shorelines and bottom elevations so that a balanced interspersion of open water and vegetated patches develops. This arrangement allows for water circulation around vegetation patches and for nutrient flush out of a wetland. An outlet or location adjacent to standing or flowing water is required for export of nutrients; an optional inlet allows for flushing.

Select sites and design the wetland for seasonal flooding. Dry periods are favorable for decomposition of plant matter and wet periods for nutrient flushing. Areas of sheet flow allow for maximum opportunity for contact with plants and removal of nutrients. Conversely, non-depositional channel flow (0.3 to 1.5 ft/s during peak annual flow) is required for transport and export of nutrients.

3.3.6 Ground water recharge

The ability for planned wetlands to provide ground water recharge is greatly site-dependent. Underlying soils and stratigraphy must be porous to allow infiltration to the ground water. Often, suitable sites occur where the topography and the ground water table slope sharply downward. Large volume basins and floodplains may more likely provide ground water recharge, and sometimes a long retention time will also promote this function (Adamus *et al.* 1987).

3.3.7 Biological diversity and abundance

Planned wetland design for biological diversity and abundance will need to be modified to match specific requirements of desired species. In general, the presence of diverse habitat types will encourage a more diverse species assemblage. Varying water depth, water velocity, substrate, and vegetation structure will lead to creation of different habitat types. Suitable cover, such as islands, adjacent upland cover, or wide stands of aquatic vegetation, should be provided, as well as an adequate food supply. Interspersion of vegetation and open water may also be important. For example, a ratio between 70:30 and 40:60 of vegetated areas to open water can be designed to provide for food and movement of fish. Inlets and outlets should be designed to allow for movement of colonizing organisms throughout the system of wetlands.

Artificial nesting structures may also be incorporated into the wetland to attract and protect waterfowl. Planting trees that form cavities in a relatively short time can encourage cavity nesting species such as bats, wood ducks, and tree swallows.

3.3.8 Recreation and aesthetics

Appropriate human use of wetlands includes passive recreational activities such as hiking, nature photography, and bird watching. Development near planned wetland sites should be minimal and unobtrusive and the degree of development within the site proportional to its size. At sites smaller than 1 hectare (2.5 acres), a trail, parking area for one or two cars, and an interpretive sign may be all the site development needed to provide for an enjoyable experience. At sites larger than 2 hectares (5 acres), viewing platforms and boardwalks may be added to the list of amenities.

Styles, plans, and specifications for construction of structures such as boardwalks can follow those used in state and national parks, *e.g.*, structures should be made of materials that blend into the surroundings. Landscape designs should channel foot traffic away from sensitive areas. Nonwetland buffer areas may be the most suitable for heavy human use.

In rare instances the goal of a planned wetland may be for visual aesthetics rather than ecological functions. This is most appropriate in locations where opportunity for public viewing and education is high. The objective here is to model a natural community while emphasizing that wetland's appearance. Either of two approaches may be used to achieve this objective: 1) selecting the individual "visual essence species," or 2) selecting and arranging plants by community. The visual essence species symbolizes a natural community and is selected

for its singular beauty, texture, color, and form. For example, bald cypress (*Taxodium distichum*) is a dominant or "visual essence species" of Illinois cypress swamps, and symbolizes the southern Illinois Coastal Plain Natural Division. The community approach attempts to model and accentuate the characteristic line, form, color, texture, or pattern of the natural wetland community in landscape plantings (Hightshoe 1985; Morrison 1987). The color and texture of a natural Illinois backwater wetland is accentuated by selecting only one or two species of the community's showy, large-flowering, emergent plants, such as lotus (*Nelumbo lutea*). The plants are arranged in drifts to simulate natural patterns. In each approach, no attempt is made to create a scene in every detail. Wetlands designed for visual aesthetics may require additional management to maintain the desired appearance.

3.3.9 Natural heritage

Although the essence of natural heritage actually takes many years to achieve, attempts can be made to restore this function at project sites. Design should follow as closely as possible the function and form of presettlement wetland communities within the natural division of the planned wetland site. Establishing habitat for threatened or endangered species is also an appropriate effort toward this goal.

3.4 Site and topographic surveys

Before design concepts are translated into site plans, a preliminary survey needs to be conducted to determine project boundaries and identify additional property that may be affected by the project. Local surveying or engineering firms, NRCS, or Soil and Water Conservation Districts can assist with site surveys. While this survey is not necessary for all projects, it is especially important in areas that have little topographic relief because drainage patterns may not be obvious. The survey can reveal information that suggests whether the project is actually feasible (Wenzel 1992).

A detailed survey will also be necessary to draft a topographic map of the basin and surrounding uplands and identify locations of boundaries, objects, and elevations (Wenzel 1992). Information should be detailed enough to make a contour map with 30-cm (1-ft) intervals (Figure 3-1). This information is essential for project design.

3.5 Design elements

The design elements described in this section can be used to promote achievement of project goals and objectives. Conditions at each individual site will require a particular combination of these elements to be incorporated into the final design plan. The more closely existing site conditions resemble those of natural wetlands that perform the desired function(s), the less complicated the design. For many suitable wetland restoration sites, such as areas more recently tiled and pastured or row-cropped, only wetland hydrology needs to be actively restored because relic hydric soils and a viable wetland seed bank exists. In other cases, *e.g.*, where the contours of the original basin have been altered more extensively, earth-moving methods and techniques are required. Complex design is nearly always necessary on created wetland sites.

3.5.1 Drainage mechanism removal

Restoration sites often occur where wetland hydrology has been altered. In these sites the drainage mechanism or source (*e.g.*, tile line, ditch, or levee) needs to be deactivated or removed. Before subsurface flow is restored, however, effects on upstream or downstream drainage systems must be determined.

Restoring wetlands in tiled pastures or fields can be quite effective. Drainage tile systems may be very complex, consisting of a main line with many lateral lines, or they may be fairly simple, with only a primary line. The lines generally range in depth from about 0.8 m (2.5 ft) deep for those installed in the late 1800's, to approximately 1.2 m (4 ft) deep for more modern systems. Tile line locations are not well documented and are often difficult to detect unless some failure or breakage has occurred. Some suggestions for finding tile systems follow (E. Collins, McHenry County Conservation District, pers. comm.).

- Consult current or former landowners who may know where and when tiles were installed. NRCS offices or soil drainage districts occasionally maintain soil drainage records.
- Look for blowouts, sink holes, or outlets in a nearby stream or ditch, and trace the line back through the field, using a tile probe.
- Study soils maps and look for elevational grades to estimate where tile lines may have been placed.
- Dig soil test pits approximately 30 cm (1 ft) deep to determine if the soil horizons have been disturbed. This may be particularly revealing if the tile lines are clay and if parts of the line are already broken.

After the location and extent of the tile system has been determined, necessary modifications can proceed. The *Minnesota Wetland Restoration Guide* (Wenzel 1992) describes three types of subsurface drainage adjustments that can be used to alter existing subsurface drains. Tile blocks simply stop the drainage capability of a subsurface tile line or system and are used primarily for small wetland basins with small drainage areas. Wetlands with larger watersheds that require an outlet and water level control may be best served by tile blocks with

inlet adjustments (Figures 3-3a and 3-3b). This system includes a drop inlet structure that slowly releases excess water (resulting from floods or from water level management) downstream into a tile system. When the drainage system upstream must remain functional, and land elevation or tile characteristics do not permit tile blockage or water control structure installation, then tile replacement may be preferred. In this method, a section of pervious drain tile under the wetland basin is replaced by impervious conduit, thus blocking drainage.

When tile lines are broken, tile break placement is important (Figures 3-4a and 3-4b). In heavy clay soils, the break or replacement should be located at least 15 m (50 feet) downstream from the basin edge, or, in organic or sandy soils, 31 to 46 m (100 to 150 feet) (USDA-SCS 1992a; Wenzel 1992). A length of tile approximately 6 to 9 m (20 to 30 feet) should be removed with a backhoe (Payne 1992; Wenzel 1992). Alternatively, a tile riser can be installed on the existing tile if the line is to remain intact or to control maximum pool elevation. Additional equipment that may be necessary for setting a tile riser includes an anti-seep diaphragm to prevent water from seeping into the old tile, a small concrete slab or two cement blocks to support the elbow, and a debris cover set over the riser. Periodic maintainance will be required to keep the debris cover clear (Payne 1992).

Another option is to install a DOS-IR® valve on the tile main to regulate flow through it. This method is advantageous when the tile line is connected by lateral lines from neighboring property (E. Collins, McHenry County Conservation District, pers. comm.), and allows the wetland manager to control water levels. See Appendix C, "Resource Materials and Sources," for supplier information.

Tile blocks have limited effectiveness in glacially influenced areas such as northeastern Illinois where more topographical relief exists. Although water will back up immediately behind a tile block, the lateral lines will still function to drain the upper reaches and laterals of the drainage area because sufficient grade exists. Therefore, in these ground water-fed systems, removing the entire tile system ensures the likelihood that the original hydrology can effectively be restored (E. Collins, McHenry County Conservation District, pers. comm.).

Several additional details should be considered when removing drain tile. Because tiles are usually laid on clay, digging deeper than the buried tile itself is not necessary; the clay serves as a seal for the wetland. Also, while plastic tile should be removed from the site, concrete or clay tile can be crushed in place, with soil packed on top. Finally, packing the soil after breaking and removing the tile is important. If the soil is not packed well, water will still seep through the former tile "channel" and function to drain the area (E. Collins, McHenry County Conservation District, pers. comm.).

When shallow ditches drain the project site, hydrology can be restored by simply plugging ditch lines at the outlet. Ditches more than a few feet deep should be sealed before being filled to grade, because the ditches may be deeper than the natural seal of the basin and will allow water to seep into permeable layers below (Galatowitsch and van der Valk 1994).

3.5.2 Hydraulic requirements

3.5.2.1 Retention requirements

Water retention requirements depend on the landscape position of the project site and the desired hydrology (water depth and hydroperiod) of the planned wetland. If the original wetland contours remain intact and other conditions affecting hydrology are similar, a restored wetland site typically will flood to the original pool level after artificial drainage is removed. This situation is most common in small watersheds and basins. Retaining structures are required, however, to confine the project area if the entire basin cannot be flooded because property ownership boundaries or barriers such as roads or railroad beds divide the basin (Galatowitsch and van der Valk 1994), or if complete drawdown is desired (Payne 1992).

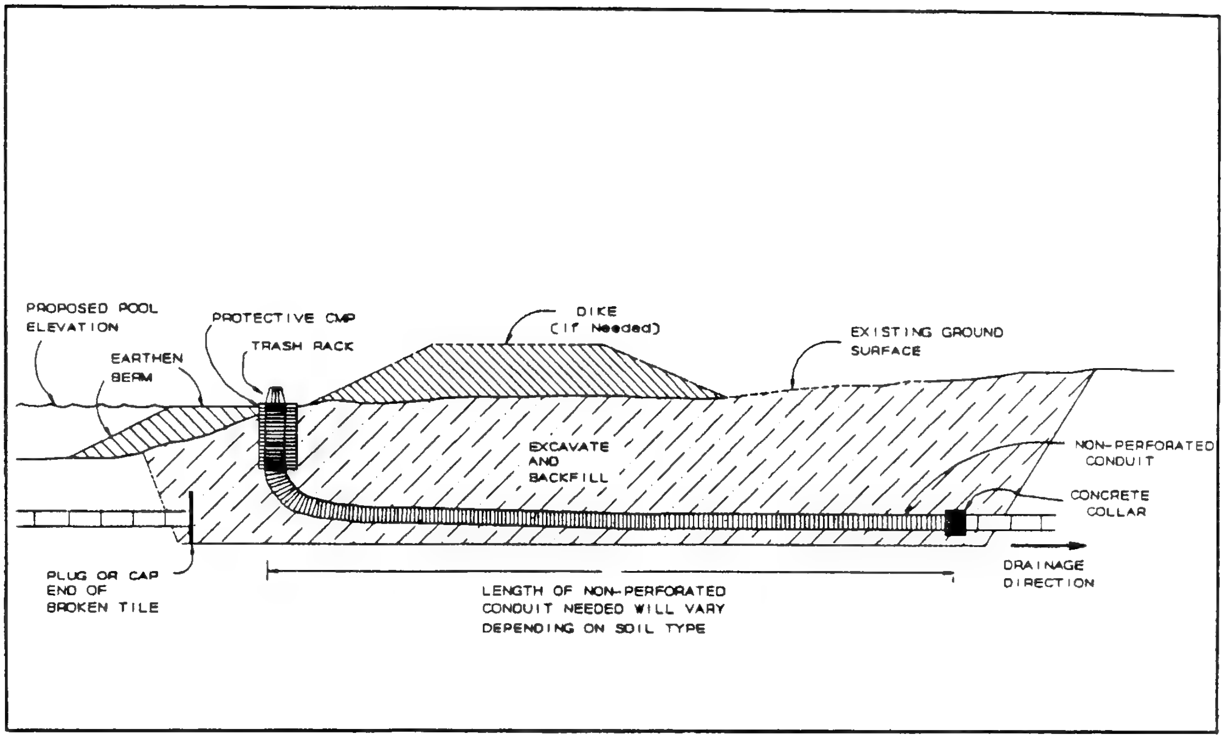
A retention or sedimentation pond on the site will be necessary to prevent degrading the planned wetland's water quality if highly erodible soils occur in upper reaches of the watershed. If soils are erodible below the wetland, water control structures and spillways can be constructed to regulate outflows (Hammer 1992). Refer to Section 3.5.2.2, "Hydraulic structures."

3.5.2.2 Hydraulic structures

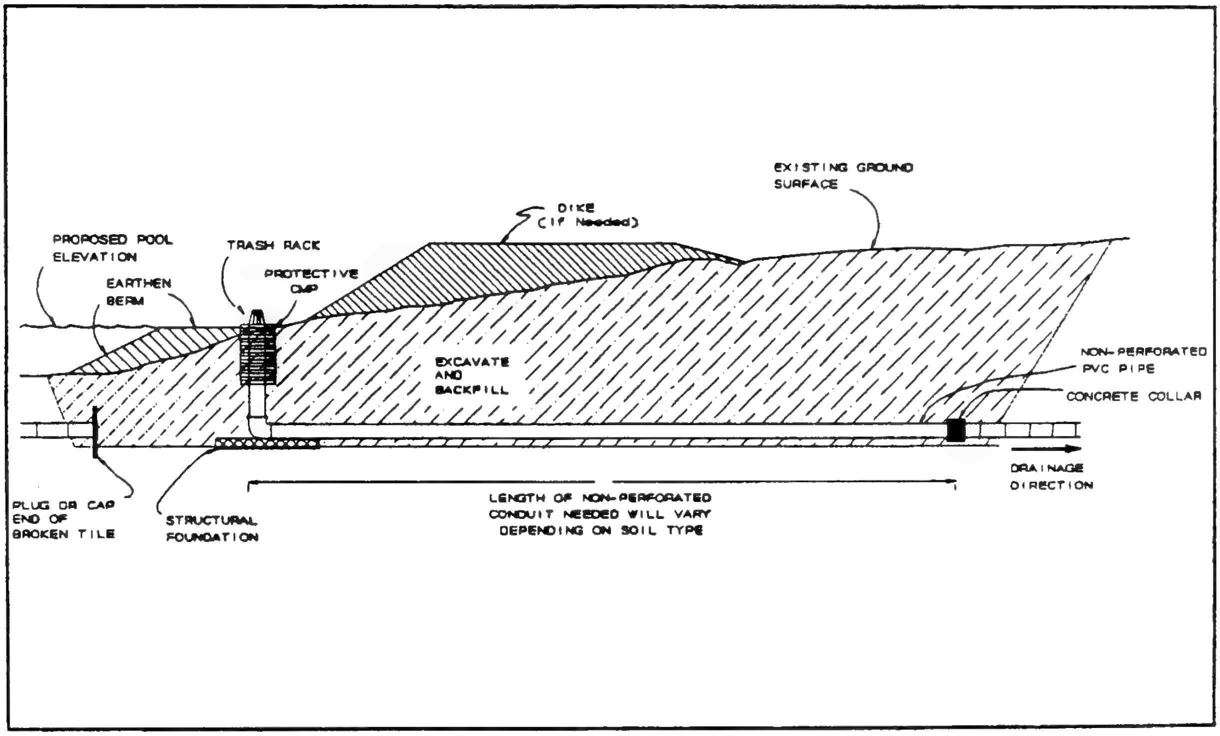
Water-containing structures

Water containing structures such as dikes, levees, and embankments are used to control flow paths and minimize short-circuiting. Dikes are embankments of earth or other suitable materials constructed to contain water or to protect adjacent land from lake, stream, and tide overflows (Myers *et al.* 1993). For wetland restoration projects, especially in rural areas, earthen dikes with a principal spillway and emergency spillway are the most common retaining structures (Galatowitsch and van der Valk 1994). Dikes can also be effective for impoundments or created wetlands where topography is relatively level (Hammer 1992).

Dikes should be constructed using foundation materials that are both impervious and stable, such as mixtures of coarse- and fine-textured soils like sand-silt, sand-clay, gravel-sand-silt, and gravel-sand-clay (Payne 1992). Soil moisture conditions are critical at this stage. Moist soils are most suitable, because dry soils will not compact well and will become very soft and weak when wet, and wet soils will not support equipment or may slough or slump. Soils should be placed in 20 to 30-cm (8 to 12-inch) layers and be compacted using hauling equip-

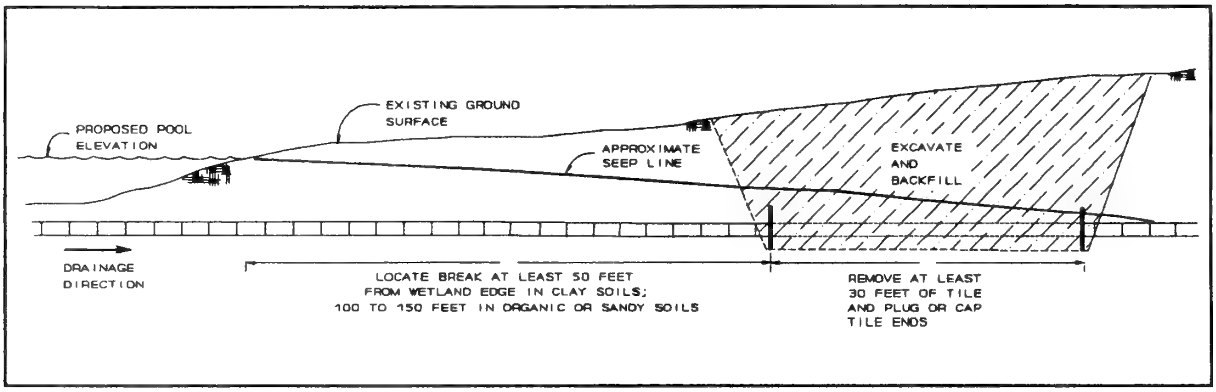


a.



b.

Figure 3-3. Tile blocks with inlet adjustments made of a) non-perforated corrugated polyethylene (PE) conduit, or b) polyvinyl chloride (PVC) conduit. Reprinted with permission from the Minnesota Board of Water and Soil Resources, Minnesota Wetland Restoration Guide, *1992.*



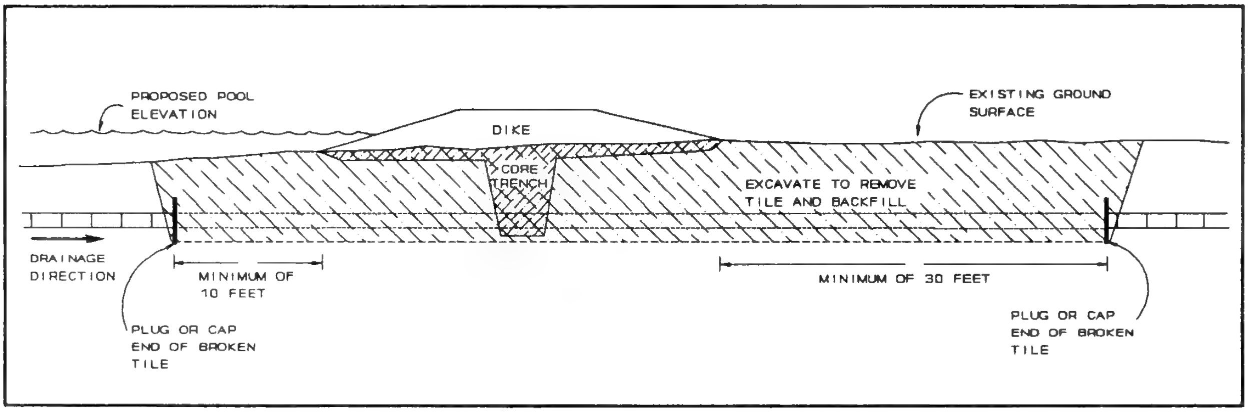


Figure 3-4. Tile blocks located a) downstream of the wetland basin, or b) under an earthen dike. Reprinted with permission from the Minnesota Board of Water and Soil Resources, Minnesota Wetland Restoration Guide, *1992.*

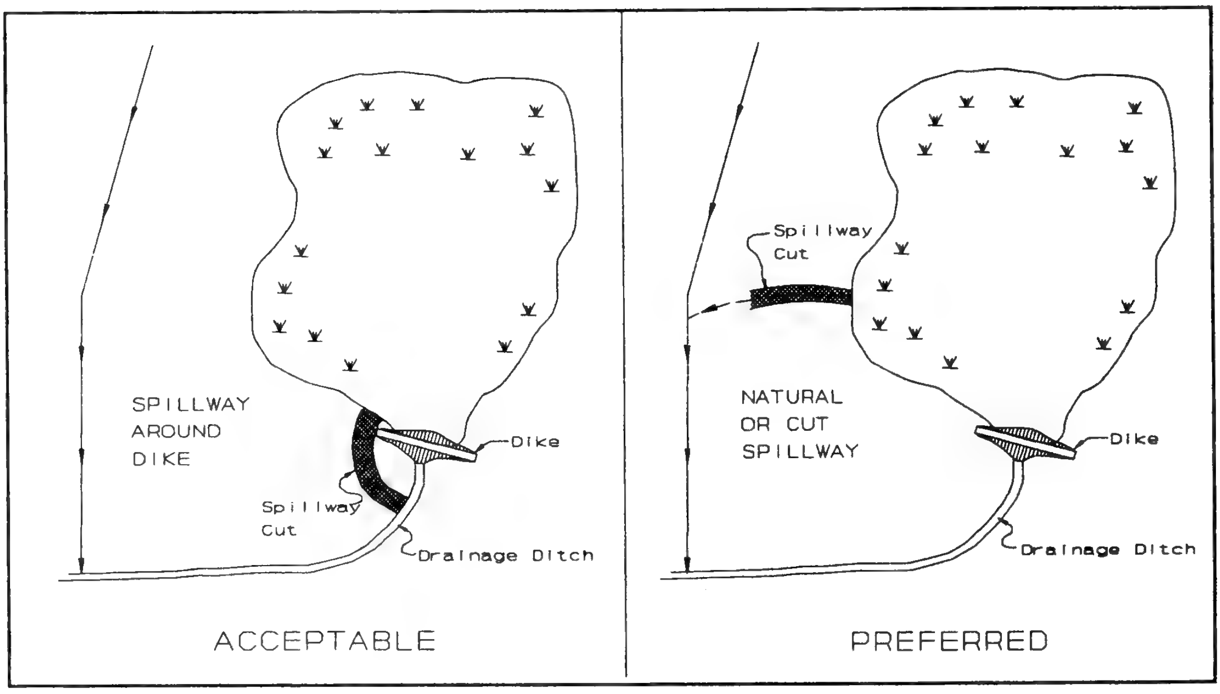


Figure 3-5. Examples of typical emergency spillway locations. Reprinted with permission from the Minnesota Board of Water and Soil Resources, Minnesota Wetland Restoration Guide, *1992.*

ment or rollers (USDA-SCS 1992a). Side slopes constructed at a 3:1 ratio (horizontal distance to vertical distance) or flatter are more stable. Dike construction techniques are further explained in Payne (1992).

Muskrat tunnels in a dike can cause dike surface collapse or dike failure. To discourage muskrats, wide dikes can be constructed that have 3 to 5 m (10 to 16 ft) top widths and slopes of 4:1 or flatter. Welded wire installed vertically within the dike also discourages muskrats (Hammer 1992). For additional methods for coping with muskrats refer to Chapter 6, Section 6.2.7, "Mechanical techniques for wildlife control."

Spillways

Spillways are constructed along with dikes in order to protect the dike during high water flows. In small, low-flow wetlands, where no water control structures are included, often only overflow spillways are designed. An overflow spillway consists of a low portion in the dike that is covered by mat-forming grasses, sedges, or rushes, or with rock riprap (Hammer 1992). Geotextile fabric or an organic mat placed over the spillway protects it from erosion during construction, before vegetation is established (Hammer 1992).

Emergency spillways are built in wetlands that have water control structures to accommodate maximum outflow expected for a design storm, *i.e.,* a storm or event of a particular frequency and duration. The spillway provides additional discharge capacity to the water control structure's flow capacity (Hammer 1992; USDA-SCS 1992a). Spillway size depends on the size and nature of the watershed and the wetland's storage capacity with regard to projected runoff volumes (Hammer 1992). Specific runoff can be calculated using methods described in the USDA-SCS *Engineering Field Handbook* Chapter 11, "Ponds and Reservoirs" (1982).

The spillway is often a straight or shallowly curved channel around one end of the dike, with vegetated 3:1 side slopes draining away (downstream) from the dike (Hammer 1992). Spillways built on natural undisturbed soil, where drainage patterns and vegetation may already exist, are preferred (Payne 1992; Wenzel 1992). Other possibilites include constructing a concrete spillway, a conduit (pipe), or a combination of a conduit with either a concrete or vegetated earthen spillway (USDA-SCS 1992a). Examples of emergency spillway locations are shown in Figure 3-5.

Water control structures

Water control structures are used to manage inflow, outflow, and drainage and are available in many types and designs (USDA-SCS 1992a; USAEWES 1993d). Water inflow can be controlled by installing an open-ended culvert pipe or building a vegetated spillway or a channel that is large enough to hold maximum design storm flows and minimize short-circuiting (Myers *et al.* 1993). Outflow control depends on the specific water elevation required to accomplish desired functions. The structures discussed in this section are typically used for outflow control.

While the selection of water control structures is largely influenced by wetland size and flow volumes, long-term operation and maintenance plans must also be considered. Generally, when water level regulation is the primary method of wetland management, the straight drop (stoplog) design and the drop inlet best meet requirements (Hammer 1992). A comparison of the two water control structures is in Table 3-2.

The stoplog type of water control is one of the most commonly used structures in small wetland systems. These also can be referred to as straight drop structures, or weirs. A stoplog structure is usually built of reinforced concrete within the dike at the lowest end of the wetland pool, and the floor of the structure opening is at or below the pool bottom (Hammer 1992). The associated spillway is usually constructed of reinforced concrete, timber piling, or corrugated steel sheet piling (Wenzel 1992). Water levels are regulated by placing or removing logs or boards in the control slots to the desired elevation. Stoplogs can be made of treated timber, metal, sheet piling, rock, or concrete (USDA-SCS 1992a). A common problem that occurs with stoplogs structures is leakage between boards and the structure. Figure 3-6 illustrates a stoplog structure.

Drop inlet structures are closed conduits that carry water under pressure from the wetland down to a lower elevation. These are usually combined with an earthen embankment in order to move a portion of runoff through or under the embankment without erosion and can be connected onto an existing tile drainage system to control water levels or discontinue drainage (Figure 3-7). Another common type of drop inlet structure, the flashboard culvert, consists of a simple metal pipe riser or whistle tube with a flashboard (stoplog) fitting (Figure 3-8) (Hammer 1992; Payne 1992). Flashboard culverts are generally used in smaller wetlands or those without greatly fluctuating inflows, where culverts have less than 0.7 to 0.8 m (2.3 to 2.6 ft) diameters (Hammer 1992).

Similar structures include a drop inlet structure with an optional gate, valve, or plug; and a pipe with a perforated riser (USDA-SCS 1992a). Level spreader inflow pipes and pumps for inflow with some type of diffuser have also been used (USAEWES 1993d). A thorough discussion about water control structures is found in Payne (1992).

3.5.3 Borrow material sources for fill requirements

Dike fill materials are usually borrowed from areas parallel to the dike or from the planned wetland basin (USDA-SCS 1992a; Galatowitsch and van der Valk 1994). For dike construction, material should consist of small gravel or coarse to fine sand

and 20% clay (Payne 1992). *Engineering Field Handbook* Chapter 13, "Wetland Restoration, Enhancement or Creation," lists soil characteristics related to dikes (USDA-SCS 1992a). Organic soils may settle, shrink, or slough excessively and should not be used. In some regions, using the clay subsoil is appropriate (Galatowitsch and van der Valk 1994). More information on borrow material is found in Payne (1992).

3.5.4 Excavation

On restoration sites, excavating part of the basin can increase the maximum water depth. Excavation can be particularly effective when a project goal is to create a permanent hemi-marsh (Galatowitsch and van der Valk 1994). However, on small restoration sites, where providing habitat for dabbling (puddle) ducks is often a goal, excavation reduces the number of shallow areas available for foraging. When slopes are steep, these waterfowl must feed near the shoreline, where they are more vulnerable to predation (Galatowitsch and van der Valk 1994).

In created wetlands, excavation to an impervious subsurface layer often is necessary for the basin to hold water. Excavation should not be deeper than designed, because the impermeable layer could be penetrated. Excavated material, if stockpiled, should be placed away from the wetland in order to prevent sedimentation into the basin. This material can be used as a windbreak, for maintaining the dike (Payne 1992), for forming nesting and loafing islands for waterfowl on deep marshes (Galatowitsch and van der Valk 1994), or for creating varied topography within the basin. Soil having a high percentage of clay may be suitable as a lining for the created wetland (see Section 3.5.6, "Lining").

Basins can be graded to simulate micro-topographic features present in natural wetlands, such as hummocks, depressions, and logs. Raised areas protect plants from inundation, and convoluted shorelines allow sediment and propagule deposition, resulting in better establishment and growth success of more species (USAEWES 1993c).

3.5.5 Consolidation of fill

If excavated soil will be graded, used for a structure, or a fill is to be made, the soil must be compacted to ensure stability. Partial compaction is accomplished by wheels or tracks of grading machinery. Compaction also can be accomplished by mechanical rolling to a specified value (USAEWES 1993b).

In planned wetland basins where the soil is somewhat permeable, soil permeability must be reduced so that the basin will hold water. Simple compaction alone can be used if the soil contains at least 10% clay mixed with silt, small gravel, or coarse to fine sands (Hammer 1992; Payne 1992). Proper compaction can be accomplished by scarifying or ripping the soil 20 to 25 cm (8 to 10 inches) deep with a disk or rototiller, adding enough moisture to lubricate soil particles, and rolling with a sheepsfoot roller to compact the bottom to a depth of 20 cm (8 inches) (Payne 1992).

Table 3-2. Comparison of water control devices (modified from Hammer, D. A., Creating Freshwater Wetlands, 178, Lewis Publishers 1992, an imprint of CRC Press, Boca Raton, Florida. With permission.).

Feature	Stoplog	Drop inlet
Flow capacity	Moderate	Low
Durability	High	Moderate
Water level regulation	High	High
Adjustment requirements	Low	Low
Ease of adjustment	Moderate	Moderate
Debris blockage	Low	Moderate
Construction cost	High	Moderate

3.5.6 Lining

Lining the planned wetland basin may be necessary when soils are coarse-grained. The particular method used for sealing the substrate of the planned wetland depends on the ratio of fine-grained clay and silt in the soil to coarse-grained sand and gravel. At least 20% clay content in the soil will reduce leakage from the basin and through dikes. Clay blankets, bentonite, and chemicals have been recommended (Payne 1992).

A clay blanket consists of layering a mixture of small gravel or coarse to fine sand with at least 20% clay over the bottom and sides of the basin and compacting each 15 to 20-cm (6 to 8-inch) layer with a sheepsfoot roller. Bentonite, a colloidal clay capable of swelling to a much larger size when wet, can be mixed with well-graded coarse-grain soil, compacted, and moistened to seal the wetland basin. Because bentonite cracks when dried, it should not be used if the wetland will undergo complete drawdown (Hammer 1992; Payne 1992). Chemical treatment may be used if the substrate soils contain at least 15% clay and 50% silt and clay in order to disperse porous aggregates of clay soil particles, but chemicals are not effective in coarse grained soils. Soils must be analyzed in the laboratory to evaluate the most appropriate dispersing agent and application rate (Payne 1992). Refer also to *Engineering Field Handbook* Chapter 11, "Ponds and Reservoirs" (USDA-SCS 1982) for more complete descriptions of the use of linings.

3.6 Components of a landscape plan

Landscape plans contain written and graphic specifications for constructing a wetland. Plans are usually drafted by a landscape architect and are presented on large, 0.6 m by 1.0 to 1.2 m

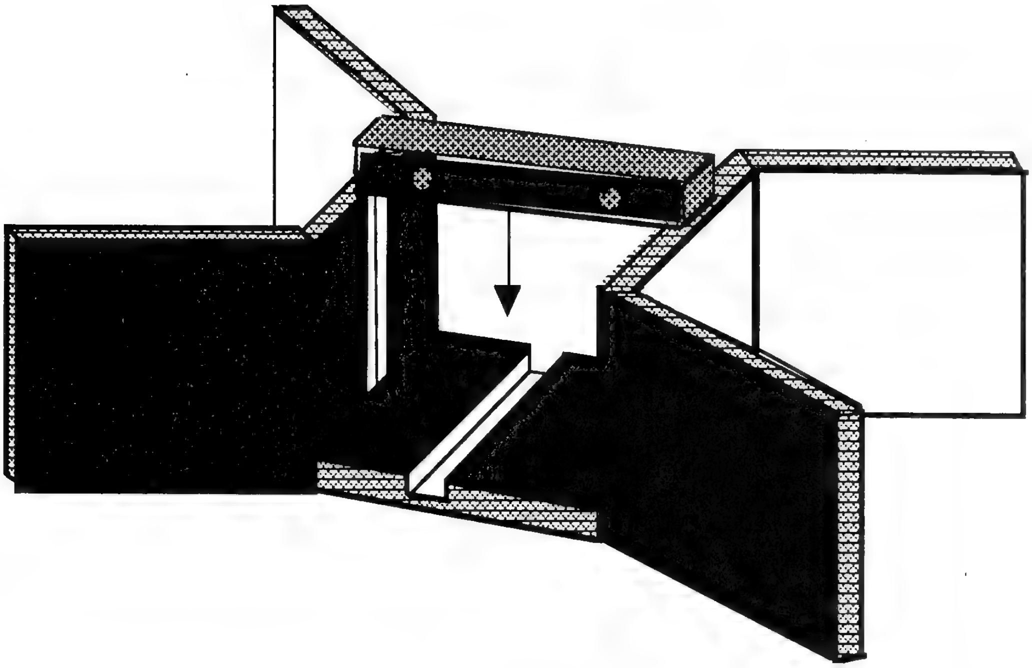


Figure 3-6. Stoplog water control structure (modified from Hammer, D.A., Creating Freshwater Wetlands, *178, Lewis Publishers 1992, an imprint of CRC Press, Boca Raton, Florida. With permission).*

(2 ft by 3 to 4 ft) sheets of paper. Except for the title sheet, each sheet should have a title block that includes the agency or consultant name, project identifier, date, initials of the designer and draftsperson, and the sheet number. A north arrow and scale must accompany landscape drawings. A scale of 1 cm=6 m (1 inch=50 ft) or less is recommended. Refer to Figure 3-9 and Appendix F, "Sample Wetland Project Documents."

3.6.1 Title sheet

The complete package of landscape plans includes a title or cover sheet. This sheet should provide the following information: project name, location map, name of preparer, date, and index of sheets.

3.6.2 Summary of quantities

Item units (*e.g.*, hectares, kilograms, and quantities) are presented in tabular form on the summary of quantities sheet. An optional column in the table includes specifications for construction materials; this may include roots (*e.g.*, balled and burlapped [B&B]), minimum ball diameter, height, and caliper (diameter) of trees and shrubs. One line item for a forested wetland is shown below:

Item no.	description	unit	root	height	caliper	quantity
708	Quercus palustris	Each	B&B	8'	——	10

Other items on a summary of quantities for a wetland may include seeding, topsoil placement, silt filter fencing, and weedy plant control.

3.6.3 Grading plans

Grading plans show the existing and proposed topography and the proposed configuration of the wetland. Existing contours are depicted as dashed lines and proposed contours with solid. The grading plan also indicates the locations and elevations of water control structures, areas to protect from construction activity, and project construction limits. Because the topography of most wetland projects is level to gently sloping, a contour interval of 0.3 m (1 ft) is recommended on grading plans.

3.6.4 Construction drawings

A separate sheet may be used to provide construction drawings. These drawings include structure dimensions and illustrate how particular structures, *e.g.*, drop inlets, are to be constructed.

3.6.5 Planting plan

The planting plan shows the location and arrangement of materials to be installed in the wetland. Letter or numeric symbols inside of circles or polygons identify the species to be planted or seeded. For example, "QP" can designate pin oak, or "5B" can denote a wetland forb seed mix. A plant materials list accompanies a design and includes the following information:

plant name (common and scientific), plant symbol (for plans using symbols), quantities, sizes, and conditions/quality.

Limited information on standard specifications for planting wetlands exist, although specifications developed for other types of plantings may be adapted for use in restored and created wetlands. The *Standard Specifications for Road and Bridge Construction* (Illinois Department of Transportation 1994) may be adapted for use in specifying wetland construction.

3.6.6 Sediment prevention plan

Construction activities (including clearing, grading, and excavation) that result in the disturbance of 2 hectares (5 acres) or more of total land area require a National Pollution Discharge Elimination System (NPDES) permit from the Illinois EPA (see Appendix B, "Natural Resources Agencies"). One requirement of a permit is a sediment prevention plan.

Sediment prevention plans comprise descriptions of the site, the controls that will be used at the site, and the regular maintenance and inspection procedures. Plans also include the following: descriptions of the nature of the construction activity and the intended sequence of major activities that disturb major portions of the site; total area of disturbance; runoff coefficient of the post-construction site; and a site map showing drainage patterns and area of soil disturbance, the location of major structural and non-structural controls, location of areas where stabilization structures are to be placed, location of surface water (including wetlands), and location of stormwater discharge.

Methods to reduce sedimentation include preserving existing trees and mature vegetation, establishing vegetated buffer strips, stabilizing substrate, temporary and permanent seeding of erodible sites, mulching, and utilizing geotextiles. Structures that can help prevent sedimentation are silt fences, earth dikes, drainage swales, check dams, sub-surface drains, gravel ditch checks, and gabions.

The sediment prevention plan also presents the intended sequence of major activities and when, in relation to the construction process, controls will be implemented. Procedures for inspections of specified areas by qualified personnel are incorporated into the plan (USEPA 1992). The U.S. EPA (1992) and the Urban Committee of the Association of Illinois Soil and Water Conservation Districts (1988) have prepared guides to developing sediment prevention plans.

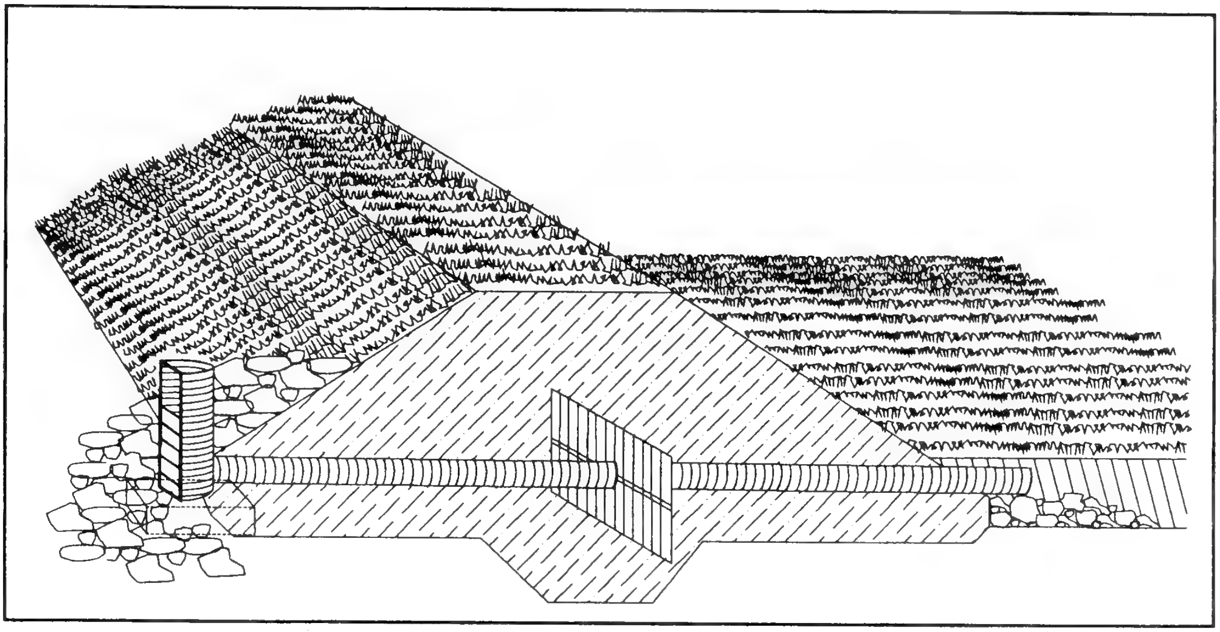


Figure 3-7. A half round riser pipe drop inlet spillway structure. Reprinted with permission from the Minnesota Board of Water and Soil Resources, Minnesota Wetland Restoration Guide, *1992.*

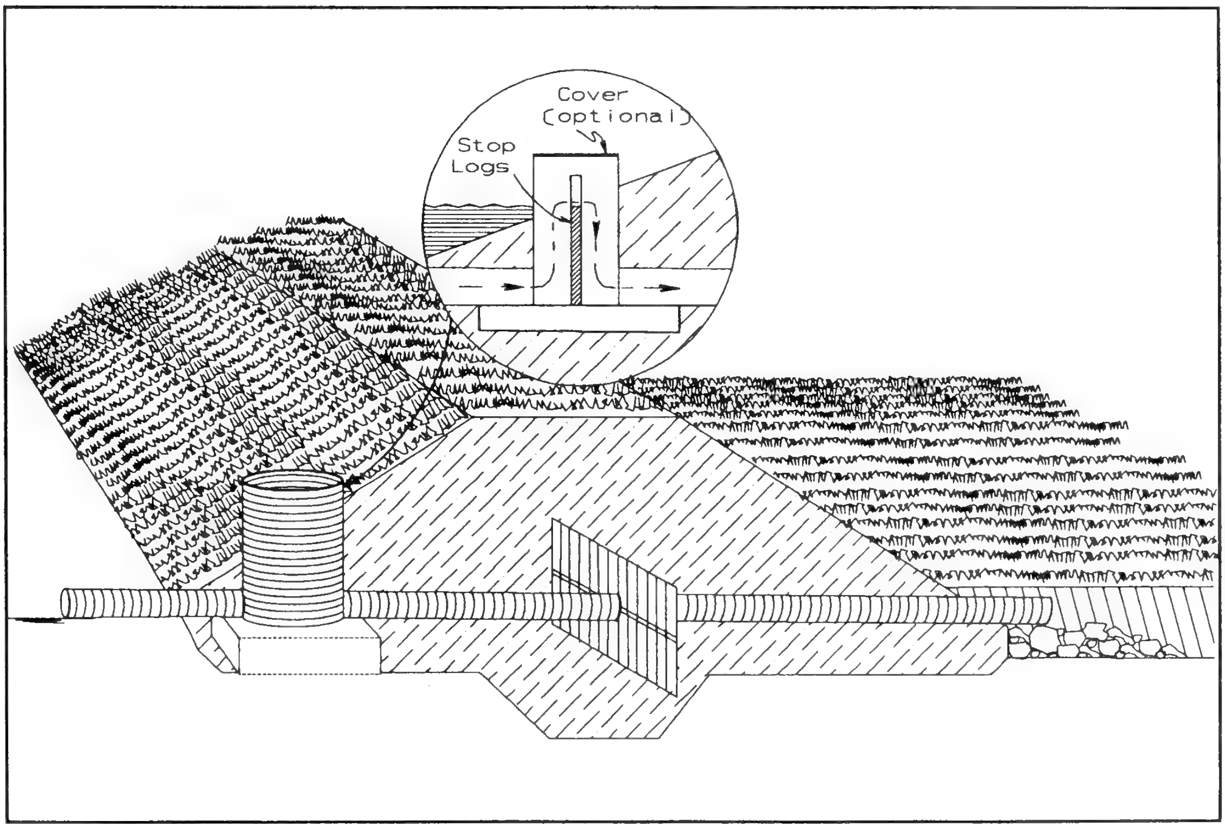


Figure 3-8. A head control stand principal spillway structure with variable crest weir. Reprinted with permission from the Minnesota Board of Water and Soil Resources, Minnesota Wetland Restoration Guide, *1992.*

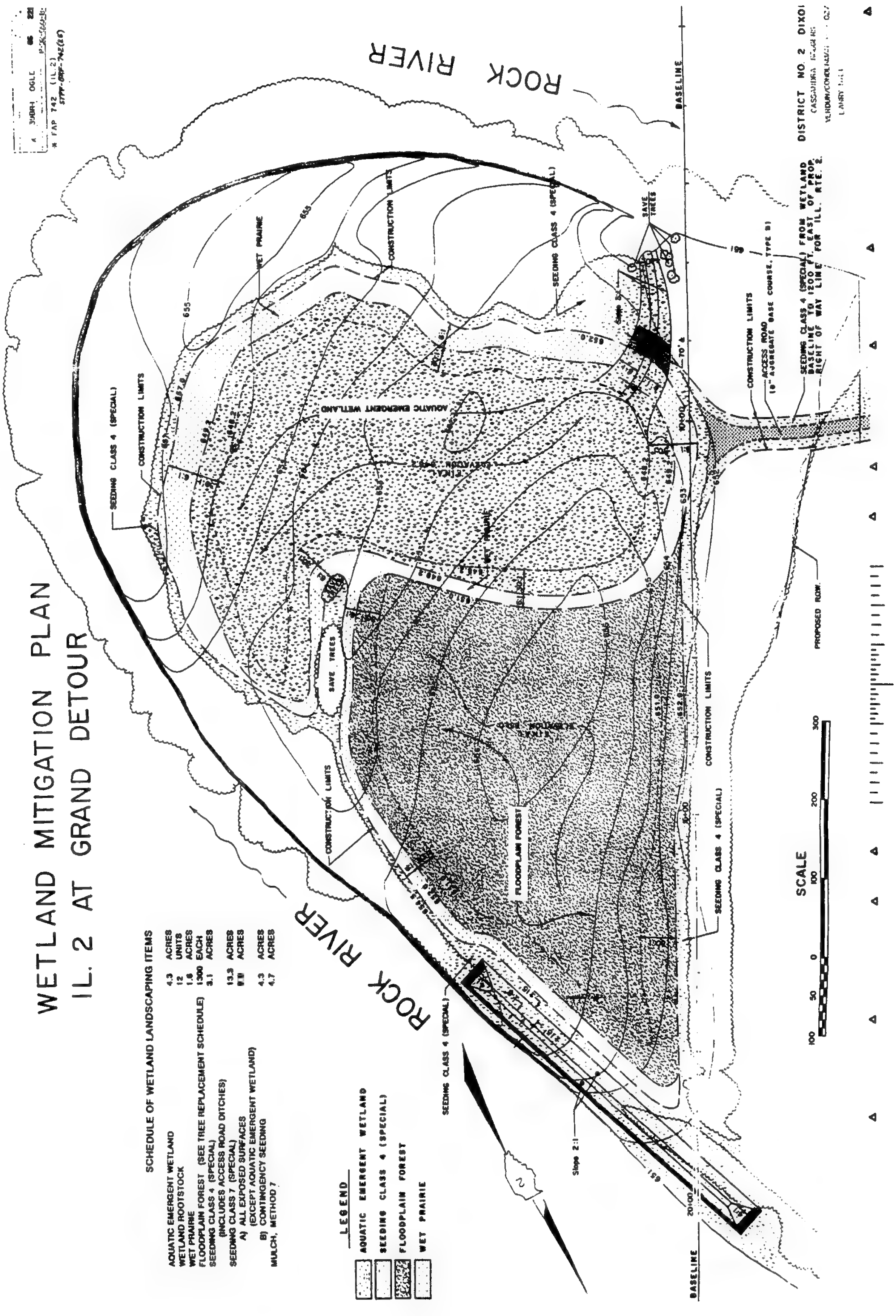


Figure 3-9. Example of a landscape plan for a created wetland.

Chapter 4 Constructing Restored and Created Wetlands—Summary

This chapter discusses factors essential to wetland construction. The topics presented are applicable to both restoration and creation projects.

- Completion of preparatory activities, such as holding prebid and preconstruction meetings and staking the site prior to construction, facilitate a smooth transition into subsequent construction work.

- Monitoring critical construction activities helps to ensure that design specifications are followed and that potential problems are identified and corrected promptly.

- A variety of equipment is available for wetland construction. Equipment selection for a given project is based on site size, soil moisture conditions, and the specific task.

- Construction primarily involves following design and grading plans. Additional activities include placing soil amendments and establishing buffers.

- Vegetation can be established by any combination of methods, including natural colonization, seeding, and transplanting. Providing favorable germination and growing conditions is essential.

- The post-construction site evaluation involves a final site inspection and documentation of as-built conditions.

The cases below describe example situations in which a wetland designer or manager would use this chapter. Guidelines and procedures in the Sections 4.1 through 4.4 and Section 4.7 apply to all projects. The remaining chapter sections can be used in some, but not all situations. For the two cases described below, we suggest the appropriate section at which to begin.

- **Case 1** Project site is a former wetland that has been tile drained but the original wetland basin is intact; the project goal is to restore biological diversity and abundance:
Because this project is a restoration, it represents an easy and inexpensive approach that has a high probability of success. Section 4.5.2, "Buffers," should be followed to establish buffer areas around the planned wetland. At a minimum, procedures in Sections 4.6.1 through 4.6.4 and 4.6.8 can be used to establish vegetation. To accelerate vegetation establishment, additional seeding or transplanting can be done (Sections 4.6.5 and 4.6.6).

- **Case 2** The project site borders an entrenched stream; the project goals are sediment removal and nutrient removal/transformation:
Follow the construction procedures in Section 4.5. Sections 4.6.1 through 4.6.3 and 4.6.8 should be consulted, but any combination of methods in Sections 4.6.4 through 4.6.7 can be used to establish vegetation.

Chapter 4
Constructing Restored and Created Wetlands

4.1 Introduction

This chapter offers guidance regarding the special considerations and requirements of wetland construction. Planned wetland construction should be completed according to the design guidelines presented in Chapter 3, "Designing Restored and Created Wetlands," in order to achieve the project goals and objectives determined in the planning stage (see Chapter 1, "Planning for Wetland Restoration and Creation").

The methods presented can be used for both restoration and creation projects. Site preparation and suggestions for monitoring construction activities are the first topics presented. The next two sections address appropriate equipment and typical construction procedures. Recommendations for establishing vegetation are then provided. Finally, suggestions for conducting the post-construction site evaluation are given.

Detailed construction specifications are not discussed; design and building of most structures requires an engineer's assistance. Supplemental construction information can be obtained from natural resources agencies (Appendix B) and other publications. Recommended companion materials to this *Guide* include Engineering Field Handbook Chapter 13, Wetland Restoration, Enhancement, or Creation" (USDA-SCS 1992a) and *Techniques for Wildlife Habitat Management of Wetlands* (Payne 1992). Engineers may find resources such as *Design of Small Dams* (U.S. Department of Interior-Bureau of Reclamation 1987) useful. *Restoring Prairie Wetlands* (Galatowitsch and van der Valk 1994) and the *Minnesota Wetland Restoration Guide* (Wenzel 1992) are helpful for wetland restoration projects.

Wetland construction is best accomplished during seasons when soils are easily worked. Generally, working in dry soils helps to minimize compaction by heavy equipment. Earth-moving in saturated soils will probably be more easily completed in winter, when the ground is partially frozen.

4.2 Preparatory tasks

4.2.1 Preliminary meetings

A prebid meeting should be held to discuss conditions of the project. Project planners, wetland designers, potential contractors, and environmental consultants involved with the project should attend. All special design conditions must be clarified, such as handling of donor soil, avoidance of existing natural areas on the site, and provisions concerning plant materials or landscaping. Work schedules and information concerning utilities may also be discussed. Contractors must be advised if the wetland work is to be included as part of a larger project bid.

A preconstruction meeting held about one month prior to commencing construction facilitates coordination during this project stage. All parties involved in the project should attend, such as wetland designers and managers, construction and landscaping contractors, engineers, hydrogeologists, environmental consultants, and landowners. The purpose of this meeting is to review applicable permit conditions, to clarify any misunderstandings about specifications, to emphasize particular aspects of the construction process, and to establish lines of communication. Specific responsibilities should be identified. In particular, an important duty is monitoring construction activities. The wetland project designer, manager, or wetland biologist will be assigned to this role and should become familiar with all phases of the project, including technical specifications and future management plans and requirements. This individual must approve any modifications to the original design (Hammer 1992).

Also at the preconstruction meeting, the parties responsible for addressing problems and implementing plan changes can be identified. A construction timetable that features steps critical to project success can be set up (Garbisch 1993). Other issues for discussion include the following (Wenzel 1992):

- work area limits
- review of design and construction specifications
- access route to site
- construction staking
- items removed by the contractor that the land owner will retain
- service interruption
- utilities notification
- disposal sites
- identification of structures, trees, etc., that will remain or be relocated
- business procedures including handling of transmittals, correspondence, inspections, requests for payments, and requests for design modifications
- time for project completion
- how to handle weather-caused delays

4.2.2 Staking

Before construction activities begin, the project site needs to be surveyed and staked. Construction staking transfers information from plans (see Chapter 3, Section 3.5.3, "Grading plans") to the project site (USDA-SCS 1982). Before the site is staked, contractors should be consulted regarding their preferences for layout and stake identification (Wenzel 1992). Lines, grades, elevations, and 0.3-m (1-ft) contours should be staked, and site access and boundaries of any proposed dams, spillways, borrow pits, impoundments, and the proposed waterline indicated (Hammer 1992; Payne 1992). Dike and spillway centerlines should be marked, and the correct dike fill and slope staked, upstream and downstream at the toe of slope. Excavation depths for borrow areas that will be used for wetland fill should be marked so that unsuitable soil materials will not be used. Locations, dimensions, and elevation of water control structures and roadways should also be staked (Hammer 1992). The project designer or manager should review all the stake locations and notations with the contractor, highlighting special methods or materials required (Wenzel 1992).

4.2.3 Preserving natural features

When existing features on the site are to be preserved and incorporated into planned wetland design (Chapter 3, Section 3.2.1, "Preserving existing features"), measures to protect these features during construction are necessary. Chain link fences or erosion fencing supported by straw bales can be used as barriers. Fences should be installed with as little disturbance to the surrounding area as possible. They must be clearly visible to equipment operators, and "no intrusion" or "protected area" signs should be posted.

4.2.4 Removing vegetation

At some planned wetland sites, landscape plans specify vegetation or soil removal (see Chapter 3, Figure 3-1). If vegetation is present where excavation will occur, vegetation or soil may be salvaged and used later as topsoil (Chapter 3, Section 3.2.2, "Salvage"; Section 4.6.4, "Natural colonization and donor soil"). However, if undesirable vegetation (*e.g.*, aggressive or weedy, native or non-native plants) is present, the vegetation or soil needs to be removed from the site or used in an area where germination and growth of propagules of these plants would be inhibited. Other vegetation removal methods include mowing, burning, or scraping.

4.2.5 Preventing erosion

Excessive erosion into wetlands results in sedimentation that can prevent adequate water level maintenance, inhibit plant growth, and reduce water quality, thereby limiting the wetland's ability to perform intended functions. The sediment prevention plan (Chapter 3, Section 3.6.6) must be imple-

mented correctly in order to prevent soil erosion into the wetland basin or into protected areas on the project site. Critical locations for erosion control include areas adjacent to haul roads, embankments, and planting zones. Silt fencing can be strategically placed around the area(s) of concern and be anchored firmly at the base using straw bales or soil. Natural vegetation preserved as a buffer around protected areas also may prevent erosion. If weeds are abundant in the buffer and cause a potential weed problem in the wetland, buffer vegetation will have to be controlled by mowing, burning, or herbiciding. Seeding a temporary cover crop, such as oats, can also help to stabilize the soil before the permanent seed mixture is planted. Erosion controls must be monitored regularly if the project is to be successful (see Section 4.3, "Monitoring tasks during construction").

4.2.6 Temporary drainage

Temporary drainage of the site may be necessary during construction to allow earth-moving. A plan for returning the hydrologic connection to the site should be associated with the drainage procedure. Temporary drainage may involve keeping the site dewatered from ground water seepage, diverting water from entering the site, postponing the hydrologic connection to the site until after construction is complete, or berming the site to prevent runoff waters from entering the site until after construction (Garbisch 1994a). On some restoration sites, often where existing wetlands are being enlarged or enhanced, shallow ditches can be routed to on-site retention ponds or to another location without permanently altering the hydrology of existing wetlands.

4.3 Monitoring tasks during construction

On-site construction monitoring is essential because mistakes, oversights, and potential design problems can be identified and corrected before further difficulties develop. The wetland project designer, manager, or wetland biologist assigned to monitoring at the preconstruction meeting (Section 4.2.1) must be on the planned wetland site during construction. This person maintains frequent contact with the project engineer and is informed about all aspects of project construction. He or she conducts routine site surveys to ensure that design specifications are followed and monitors materials handling and sedimentation, particularly in highly erodible locations and near protected natural areas. Problems should be reported to the project engineer immediately and remedied as soon as possible.

4.3.1 Design specifications

Failure to build a wetland according to design specifications may result in an unsuccessful project. An important part of construction monitoring includes verifying that wetlands have been graded according to plans. Elevations and slopes can be checked with hand-held levels. In later stages, planting materials and locations must concur with specifications. The person assigned to monitoring should be consulted concerning any modifications, and the changes indicated on the construction plans. Monitoring is conducted after critical stages of earth-moving and after construction for the entire project has been completed (see Section 4.7, "Post-construction site evaluation").

4.3.2 Sedimentation

Erosion and subsequent sedimentation are inevitable on a construction site. Excessive sedimentation can alter the planned grades and water flow in the wetland and can be detrimental to living organisms. Limiting the harmful effects of sedimentation during the early stages is extremely important. Erosion-prone areas should be checked for evidence of gully and rill formation, and silt fences checked for weakness or failure. This is particularly important if natural areas on the site require protection (see Section 4.2.3, "Preserving natural features"). Tasks also involve making sure that the sediment prevention plan is implemented correctly (see Chapter 3, Section 3.6.6). Monitoring is conducted during critical stages of earth-moving and after major storms.

4.3.3 Materials handling

Some wetland designs specify adding special materials, *e.g.*, hydric soil, donor soil, or plant material. If such material is used, its excavation and transport should be closely supervised. This material is very fragile; soil structure can be destroyed and plants will not survive if handled improperly. Soil should be obtained at the proper depth and thickness. Immediately placing donor or hydric soil in designated locations that have been prepared prior to soil removal from the donor site is optimal. Roots and sensitive plant parts need to be protected from damage and dessication (see Section 4.6, "Establishing vegetation"). Monitoring should occur at appropriate construction stages.

4.4 Earth-moving equipment

Earth-moving equipment is a major expense for planned wetland projects (King and Bohlen 1994). Whereas restoration generally requires less equipment and consequently is less costly, on created wetland sites, the landscape must be manipulated to facilitate wetland establishment, and more equipment will be needed and higher labor costs will be incurred.

All equipment must be cleaned prior to use to prevent introducing soil that contains exotic or weed seeds into the site. Equipment is selected for particular site conditions, such as

size, soil properties, and soil moisture. Generally, larger equipment is more cost-effective than smaller, especially for large projects, although impacts to soils may be greater. This class of equipment comprises draglines, crawler tractors with scrapers, crawlers with bulldozers, and front-end loaders. Additional equipment includes clamshells, sheepsfoot rollers, and graders. Dumptrucks also can be used with front-end loaders and clamshells.

Soil properties that affect the equipment used for transporting soil include bulking, defined as the increase in volume of an excavated soil compared to its original volume, because the size of the equipment needed is greater. Equipment for transporting soils includes containers such as loader-scrapers and wheeled trucks (USAEWES 1993b). It is critical that the equipment causes as little soil compaction as possible in probable planting zones. Generally, the higher the soil moisture, the greater the opportunity for soil compaction or soil structure damage.

Table 4-1 shows the suitability of particular equipment under certain moisture conditions. Bulldozers work best for many tasks, but depending on soil and moisture conditions, bulldozers with scrapers and draglines, which often cost nearly twice as much as bulldozers, may be more suitable. Draglines on log mats are useful in wet, heavy soil, and low-ground-pressure (LGP) crawlers also can be used except in very wet areas (Payne 1992). Wide-track scrapers (Ross *et al.* 1985) and hydraulic excavators (Worthington and Helliwell 1987) have been effective in soft soils. Scrapers can be used for excavating and for transporting peat (Brown *et al.* 1985).

Equipment used for dike construction includes the front-end loader, bulldozer, mobile or tow scraper, dragline, mobile or tow grader, disk, dump truck, and sometimes a backhoe, sheepsfoot roller, and farm (rubber-tired) tractor. A bulldozer can be used to remove rocks and stumps from the dike area, the scraper can remove topsoil, and the dragline or backhoe can dig out the core area. Impervious fill can be removed from a borrow pit with a bulldozer or scraper, loaded by a front-end loader or clamshell into a dump truck, dumped onto the dike area, and spread and compacted with the bulldozer (Payne 1992).

Specialized equipment will be needed to establish vegetation on the project site. Equipment for this purpose is discussed in Section 4.6.1.

4.5 Additional construction tasks

Much of the construction phase involves implementing design guidelines described in Chapter 3, Section 3.5, "Design elements." Items described in this section are additional activities that may be necessary to successfully accomplish project goals and objectives.

Table 4-1. Construction equipment vs. site conditions (from USDA-SCS 1992a and Payne 1992). "D" denotes use on dry ground, "S" denotes use in saturated soil, and "W" denotes use in shallow water (less than 0.6 m [2 ft] deep).

Equipment	Site conditions
root grubber	D, S
disk/plow	D
harrow	D
backhoe	D, S
bulldozer	D, S (sand), W
scraper (road grader)	D, S
dragline	D, S, W
hydraulic excavator	D, S (sand), W
special wide tracks	S, W
rubber-tracked equipment	S, W

4.5.1 Soil amendments

Soils are amended to improve fertility or reduce bulk density or compaction. The presence of organic matter is particularly critical in areas where vegetation will be established, because organic soils have a higher buffering capacity than mineral soils (Kentula *et al.* 1992), and plants utilize the nutrients that are found in organic material. However, soil organic matter takes time to develop naturally. On wetland restoration sites, soils may still have a significant proportion of organic matter. However, organic matter may be deficient in created wetlands sites where surface soil horizons have been excavated. A topdressing consisting of leaf or grass compost, composted livestock bedding and manure (although seeds of aggressive weedy species may be present if not composted properly), and food processing wastes may enhance organic soil material development (Kentula *et al.* 1992). Also, substrate from a donor wetland may be used. In sedge meadows, compost especially has been shown to greatly improve soil physical properties and subsequent soil moisture and hydrologic characteristics (Bremholm 1993). This technique is discussed further in Section 4.6.4, "Natural colonization and donor soil."

4.5.2 Buffers

Buffer areas are constructed according to guidelines discussed in Chapter 3, Section 3.2.3 and Sidebar 3A. In most cases it is advantageous to establish buffer vegetation prior to or when the planned wetland is under construction to protect it from sedimentation. Buffer vegetation can also be established at the same time that wetland vegetation is planted. Section 4.6, "Establishing vegetation," provides information about appropriate planting techniques.

4.6 Establishing vegetation

Establishing plant communities is a critical aspect of the construction phase. Vegetation helps stabilize substrate and create organic material for soil development in the planned wetland. It is an essential component for achieving many wetland functions, *e.g.*, production export and wildlife habitat. In surrounding buffer areas, established vegetation helps to maintain wetland integrity and function.

Vegetation establishment procedures are discussed in this section. The method selected for establishing vegetation is influenced by the intended goals of the project, the wetland community type, the physical and biological conditions at the site, surrounding land use, scheduling, and availability of desired species. Additional considerations include maintaining optimal conditions for establishment. These planting techniques can also be applied to buffer areas at the site.

4.6.1 Equipment

A variety of equipment is useful for establishing vegetation. The type of equipment used depends upon the particular task, the type of plant material involved, and the size of the site. If plant material will be collected from local sources, relatively little equipment is required. Harvesting seeds is usually done by hand. Modified combines have been used where conditions are drier and stands of a particular species are continuous (Marburger 1992). Simple hand tools such as tile spades can be used for digging plugs, rhizomes, and rootstocks.

A disc and harrow are usually necessary for site preparation. Rollers or cultipackers are also useful for breaking up clods, as well as for covering newly planted seeds with soil. Front-end loaders are used to obtain donor soil, dump trucks transport the soil, and small bulldozers or scrapers place the soil at the receptor site.

No-till planters and seed drills designed specifically for planting native grasses and forbs may be the most typical seeding equipment. Other types of seeding equipment include hydro seeders, which spray a mixture of water, mulch, and seeds; hydraulic seeders, which keep seeds in suspension in water; spinning disc seeders, which mix seeds with a particular dispersal medium before sowing; and tractor-drawn or mounted seeders, usually mounted on cultipack rollers (LaFayette Home Nursery 1991b). All-terrain spreaders (modified salt trucks that broadcast the seed) can also be used (Galatowitsch and van der Valk 1994). For sites less than 0.4 hectare (1 acre) in size, hand-broadcasting seed is feasible.

For direct oak seeding in large, open areas, modified soybean planters have been used (Johnson and Krinard 1987). Smaller areas can be planted by hand (Johnson and Krinard 1987; Allen and Kennedy 1989). Equipment needed for transplanting plugs, rhizomes, tubers, corms, and rootstocks of emergent species consists primarily of hand tools such as dibble bars (Figure 4-1) and trowels (Marburger 1992). Tree seedlings can be hand-planted using a dibble bar or sharpshooter shovel (tile spade) (Allen and Kennedy 1989). In dry conditions, tractor-drawn seedling tree planters can be used to plant plugs, tubers, etc., as well as tree seedlings. Sharpshooter shovels can also be used to plant larger trees, *e.g.*, balled and burlapped.

4.6.2 Substrate preparation and scheduling

After areas to be planted have been finished to grade, removing debris and making a smooth planting bed at the project site are important for many reasons. Planting and maintenance will be less hazardous and less expensive, plantings will not be scoured by floating debris during flooding, and post-establishment monitoring will be facilitated (Clewell and Lea 1990).

Similar substrate preparation tasks are performed for natural colonization and seeding techniques. For regulatory projects, soil compaction may need to be evaluated before planting can begin (see Section 4.7, "Post-construction site evaluation"). To prepare the substrate for natural colonization of forest vegetation, undesired vegetation should be removed before the dormant season by disking, harrowing, or other methods (Clewell and Lea 1990). Additional disking, harrowing, and/or rolling may be necessary to break up clods and loosen the soil for proper root development. Soil preparation specifications often state that topsoil should be free of stones, roots, sticks, rivulets, gullies, crusting, or caking. Soil particle size should be less than 5 cm (2 inches) (LaFayette Home Nursery 1991b).

Interseeding is a no-till seeding method that involves planting seeds directly into existing vegetation. On areas designated for interseeding, undesirable vegetation can be treated with herbicide but not disked or tilled, in order to provide a more stable planting bed. Seeds can be planted directly into the dead vegetation (E. Collins, McHenry County Forest Preserve District, pers. comm.). Alternatively, the following actions can be taken in the year before a scheduled seeding. Existing vegetation can be mowed and plowed to a depth of 22 cm (9 inches) during the summer before planting, so that during the winter some weed roots may be killed by freezing and thawing. The area can be disked, harrowed several times to level the ground surface and to expose existing roots, and lightly cultivated to get rid of weeds as they germinate the following spring. A cultipacker can then be used to firm up the seed bed for planting (Galatowitsch and van der Valk 1994).

Timing for establishing vegetation is critical. Seeding, planting, or transplanting within the planned wetland is most successful after the hydrology of the wetland, *i.e.*, open water area, depth, and hydroperiod, is known. In some cases, temporary drawdown may be necessary to allow the plants to

Table 4-2. Suggested species for various stages of revegetation. Plants that recolonize without planting in restored wetlands may need to be planted at created wetlands. Stage 1 species can be mechanically seeded, Stage 2 plants are hand-seeded, and Stage 3 plants are transplanted as seedlings or plugs. Sedges and those otherwise noted should be planted using plugs. Modified from Galatowitsch and van der Valk 1994.

Plants Often Recolonizing Without Planting	Stage 1 Plants	Stage 2 Plants	Stage 3 Plants	Weedy Plants To Be Avoided
Wet prairie				
Aster simplex	*Andropogon gerardii*	*Anemone canadensis*	*Carex gravida*	*Agropyron repens*
Ambrosia spp.	*Calamagrostis canadensis*	*Asclepias incarnata*	*Carex stricta*	*Cirsium arvense*
Bidens spp.	*Desmodium canadense*	*Aster novae-angliae*	*Chelone glabra*	*Helianthus grosseseratus*
Elymus canadensis	*Elymus canadensis*	*Aster puniceus*	*Cicuta maculata*	*Lythrum salicaria*
Erigeron spp.	*Epilobium coloratum*	*Eupatorium perfoliatum*	*Gentiana andrewsii*	*Melilotus alba*
Verbena hastata	*Helenium autumnale*	*Liatris pycnostachya*	*Gentiana puberulenta*	*Phalaris arundinacea*
	Panicum virgatum	*Phlox pilosa*	*Lilium michiganense*	*Phragmites australis*
	Ratibida pinnata	*Pycnanthemum virginianum*	*Lythrum alatum*	western strains of prairie grasses, *e.g.*, Blackwell switchgrass
	Silphium perfoliatum	*Stachys palustris*	*Pedicularis lanceolata*	
	Silphium lanciniata	*Teucrium canadense*	*Phlox glaberrima*	
	Spartina pectinata (plugs)	*Veronicastrum virginicum*	*Thelypteris palustris*	
		Zizia aurea	*Tradescatia ohiensis*	
Sedge meadow				
Bidens spp.	*Aster* spp.	*Asclepias incarnata*	*Carex lacustris*	*Cirsium arvense*
Carex vulpinoidea	*Eupatorium perfoliatum*	*A. novae-angliae*	*Carex lanuginosa*	*Helianthus grosseseratus*
Cyperus spp.	*Eupatorium maculatum*	*Aster puniceus*	*Carex stricta*	*Lythrum salicaria*
Juncus dudleyi	*Glyceria striata*	*Aster umbellatus*	*Gentiana andrewsii*	*Phalaris arundinacea*
Juncus torreyi	*Mimulus ringens*	*Calamagrostis canadensis*	*Gentianopsis crinita*	*Phragmites australis*
Leersia oryzoides	*Stachys palustris*	*Chelone glabra*	*Pedicularis lanceolata*	*Typha angustifolia*
Rumex altissimus	*Verbena hastata*	*Lycopus* spp.		*Typha latifolia*
		Lysimachia spp.		
		Scutellaria spp.		
Shallow emergent plants				
Eleocharis erythropoda	*Alisma* spp.	*Acorus calamus*	*Carex atherodes*	*Lythrum salicaria*
Eleocharis obtusa	*Carex cormosa*	*Iris virginica*	*Carex lacustris*	*Phalaris arundinacea*
Polygonum amphibium	*Carex lupulina* (S. IL)	*Lysimachia thrysiflora*		*Phragmites australis*
Polygonum hydropiper	*Carex lupuliformis* (S. IL)	*Sium suave*		
Polygonum pensylvanicum	*Carex squarrosa*			
Rumex orbiculatus	*Carex spp.*			
Rumex verticillatus	*Eleocharis palustris*			
Scirpus atrovirens	*Eleocharis spp.*			
Scirpus fluviatilus	*Sagittaria spp.*			
Typha latifolia	*Sparganium eurycarpum*			
Deep emergent				
Scirpus acutus	None	None	*Ludwigia palustris*	*Phragmites australis*
Scirpus tabernaemontanii (S. validus)				*Typha angustifolia*
Submerged aquatic				
Ceratophyllum spp.	None	*Potamogeton spp.*	*Vallisneria americana (N. IL)*	*Myriophyllum spp.*
Najas spp.		*Ranunculus flabbelaris*		*Potamogeton crispus*
Potamogeton foliosus		*Ranunculus spp.*		
Potamogeton nodosus				
Potamogeton pectinatus				
Potamogeton zosteriformis				
Utricularia vulgaris				
Floating aquatic				
Lemna minor	None	None	*Nuphar luteum macrophyllum*	None
Lemna trisulca			*Nymphaea tuberosa*	
Spirodela spp.				
Wolffia spp.				
Wolffiella spp.				

Table 4-2 continued

Plants Often Recolonizing Without Planting	Stage 1 Plants	Stage 2 Plants	Stage 3 Plants	Weedy Plants To Be Avoided
Mudflat annual				
Cyperus spp. *Eleocharis* spp. *Echinochloa crusgalli* *Amaranthus* spp. *Bidens* spp. *Polygonum* spp.	*Carex* spp. *Eleocharis* spp.	None	None	None
Woody				
Acer negundo *Acer saccharinum* *Populus deltoides* *Salix exigua*	*Cephalanthus occidentalis* *Cornus* spp.	None	*Populus heterophylla* (S. IL) *Taxodium distichum* (S. IL)	*Rhamus frangula*

become established (see Chapter 6, Section 6.2.1, "Water level manipulation"). A temporary cover crop will help to stabilize soil. Various species can be planted in the proper location in relation to water level and develop stable root systems before the area is flooded.

Seeding as well as transplanting sedges is best accomplished in the spring, rather than in the fall when frost-heave and predation by rodents are threats. Successful planting of tubers of other plants such as burreed (*Sparganium* spp.), bulrush (*Scirpus* spp.), and arrowhead (*Sagittaria* spp.) has been accomplished in the fall (Galatowitsch and van der Valk 1994). Direct seeding of trees is most commonly done in fall, spring, and early summer (Allen and Kennedy 1989). For some southern oaks, less rodent predation occurred when acorns were planted in the winter (Johnson and Krinard 1987).

Galatowitsch and van der Valk (1994) have summarized information based on prairie restoration that advocates planting wetland vegetation in stages. Table 4-2 provides suggestions for staged planting plans implemented in Illinois. The staged planting approach is effective because it follows a more typical succession of species. Stage-1 species are fast-growing, aggressive grasses and forbs that complement or enhance the composition of naturally colonizing species. These species can be mechanically seeded. After one year, wet prairie and sedge meadow communities can be burned to control annual weeds. Weedy vegetation usually declines after two to three years, and slower-growing, Stage-2 species are hand-seeded into the area. Sowing this forb seed in patches not only matches distribution in existing wetlands but also helps to reduce competition from grasses. Stage-3 species usually inhabit more stable environments and are more sensitive to competition from weeds or other native species. Seedlings of these species can be transplanted to pots for a season, and the second-year plants transplanted into well-established planned wetlands. This stage is reached approximately five to six years after the initial seeding.

4.6.3 Plant material sources

Many commercial nurseries in the Midwest supply a variety of wetland plant species. Appendix N, "Commercially Available Illinois Native Plant Species," contains a comprehensive list of wetland plant species offered by Midwest nurseries. The best strategy is to obtain native plant material from nurseries in the same region (within 320 km [200 miles]) as the project location. Native plant species are less likely to spread uncontrollably and become a problem (Payne 1992). This material is more likely to be an ecotype comparable to locally-occurring plants and therefore better adapted to regional environmental conditions. Similarly, species cultivars and horticultural varieties should be avoided.

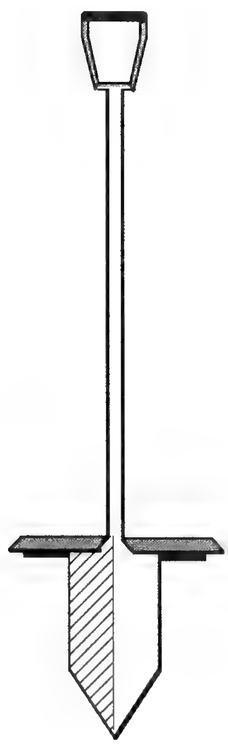


Figure 4-1. Dibble bar, used for transplanting vegetation.

Wetland plant seeds may be obtained from local wetlands in some situations if the land owner's permission has been granted (LaPré and Morris 1994). For example, large populations of New England aster (*Aster novae-angliae*) may exist in a privately owned wetland, and the owner may permit seed collection in the fall. Seeds of wetland plants do not ripen at the same time, so they need to be harvested when most seeds are mature (Marburger 1992). The seeds can be planted directly at the planned wetland site, or stored for later propagation at the site or in a greenhouse. In a greenhouse, the seeds can be germinated and grown in a soft growing medium (such as a vermiculite and sand mixture) until the seedlings reach the appropriate size for transplanting (USAEWES 1992a). One option is to contract with a nursery to grow plants from propagules collected from a local site. Note that sufficient time (*e.g.*, one to two years) is required for collection and growth so that the plants will be a viable size when they are to be transplanted into the planned wetland.

Wetland plants may be dug from local wetlands if the wetlands are scheduled to be destroyed. Vegetative organs such as rhizomes, tubers, and rootstocks have greater survival if they are dug in the spring and planted immediately, but high water levels in the natural wetland in the spring may limit collection (Marburger 1992). Plant material can be installed directly at the project site or transplanted to pots for later use. Setting up nurseries on the site for transplanted stock is also possible (Marburger 1992). This technique involves digging 30 to 60-cm (12 to 24-inch) deep pits into the soil, lining them with plastic to maintain moisture, and filling with 20 to 30 cm (8 to 12 inches) of topsoil. Water should be supplied by a surface or, preferably, a subsurface irrigation system.

Designers or managers should ensure that the material they order is propagated in environmental conditions similar to planned wetland site conditions. For example, bald cypress (*Taxodium distichum*) grown in moist, loamy soil may not transplant successfully into planned wetlands with poorly drained or inundated, heavy clay soils.

4.6.4 Natural colonization and donor soil

Natural colonization refers to vegetation establishment without actively adding seeds, transplants, or other plant propagules to the soil. Propagules are generally supplied from the seed bank or from neighboring wetlands. Plant community establishment by natural colonization occurs more slowly but incurs less cost. The resulting species diversity and densities may be similar to seeding or planting.

On some restoration sites the seed bank may be adequate for establishing a diverse plant community. Seeds of some wetland plant species can lie dormant in the soil seed bank for many years (Frankland *et al.* 1987; Weinhold and van der Valk 1989). If the donor site has been drained, the content and viability of the seed bank is affected by the duration of drainage. In restored agricultural sites in Iowa, Minnesota, and South Dakota, the mean number of seeds in the seed bank decreased with duration of drainage, although seeds of some species remained viable as long as 40 years. Seed survival may also be affected by agricultural practices such as the extent and efficiency of drainage, the type of herbicides applied, the methods of cultivation used, and the crops planted (Weinhold and van der Valk 1989). Because seeds of wetland species have different germination requirements, the floristic composition of a site may vary in response to particular environmental conditions that allow only certain species to germinate (van der Valk and Davis 1976, 1978). For example, if seeds of some of the original wetland species that require greater moisture levels are present in the seed bank and are still viable, they will germinate and grow when favorable wetland hydrology returns to a wetland area that had been drained. Managers can determine the species composition of the seed bank by collecting soil from the site, placing it in pots, and maintaining favorable germination conditions for several months until seedling emergence ceases. Refer to Galatowitsch and van der Valk (1994) for a more complete description of the seed bank assay technique.

Occasionally suitable donor soil material can be salvaged from a wetland that is being destroyed and can be applied in a planned wetland. When wetlands are destroyed for development, hydric soils typically must be removed because they are unsuitable for fill. Intact wetlands should never be disturbed for this purpose. Not only do wetland soils comprise a seed bank and other plant propagules (rhizomes, tubers, etc.), the soils may contain mycorrhizae (fungi that make nutrients, particularly phosphorus, available to plants) (Garbisch 1993). These soils also provide the necessary structure for wetland plant growth. Generally only the top 20 to 25 cm (8 to 10 inches) are removed and used as donor soil (Galatowitsch and van der Valk 1994). In seed bank studies, numbers of seeds and numbers of species have been higher in this portion of the soil profile than in deeper horizons (Moore and Wein 1977; Naim 1987; Pederson and Smith 1988).

Topsoiling produces variable results for different wetland plant communities, hydrologic regimes, and geographic regions (Garbisch 1993). Adding topsoil also increases project cost. Before topsoiling, wetland designers or managers should consider seed bank composition and measures to control invasive or undesirable plants, the method of spreading soil that will promote germination and growth of most plant parts, the effect that excavation and spreading the soil will have on soil structure, and whether water levels should be managed to assure seed germination and seedling emergence (Garbisch 1993). Soil that contains large numbers of weedy species is not suitable. Several years may be needed before the full species

complement and density are realized, especially in locations that are more isolated from other seed sources (Clewell and Lea 1990).

Salvaged soil must be handled carefully. Stockpiling is not recommended; the acceptor site should be ready to receive donor soil immediately (K. Bowers, pers. comm.). If immediate placement of donor soil is not possible, the maximum duration of storage is 30 days because storage may result in the loss of viability of some seeds and may allow the release of metals that will be toxic to seedlings (Kentula *et al.* 1992). If both A and B soil horizons have been stockpiled, the original arrangement (A above B) should be recreated at the acceptor site so that the the topsoil containing the seed bank and providing a substrate for plant growth will be placed on top.

If a planned wetland site is adjacent to or near (within 1 km [0.6 miles]) intact wetlands of the same type, natural colonization may be an effective vegetation establishment method. These wetlands provide a source of wetland plant propagules because seeds are transported naturally by wind, water, or animals. For example, submerged species often reach the planned wetland on the bodies of waterfowl or other wildlife. For regeneration of heavy-seeded, woody plant species, only sites directly adjacent to a suitable seed source (no greater than two tree heights from surrounding seed sources), exposed to seed-bearing floodwaters, or where the original soil and hydrologic regime have been altered very little are suitable for natural colonization (Clewell and Lea 1990). Types of plants that are not represented in the seed bank and/or have poor dispersal patterns, such as some sedge meadow species, will have to be seeded or transplanted into the wetland (Galatowitsch and van der Valk 1994).

Natural colonization is often used for establishing forested wetland understories, because shade-tolerant species will eventually colonize as the trees mature and form a canopy. If wind or water erosion at the site is a problem, natural colonization should be relied upon as a supplement to other primary methods of establishment, because the colonizing vegetation may not establish quickly enough to stabilize exposed soil. Often, seeding a temporary cover crop (nurse crop) such as oats is used to stabilize the soil while naturally colonizing species become established.

4.6.5 Seeding

In restoration sites that contain excavated basins or that were thoroughly drained and cultivated for more than 20 years, few wetland plant seeds will be present in the seed bank, and seeding will be required (Galatowitsch and van der Valk 1994). For created wetland sites, seeding is commonly used to establish vegetation. Seeding has been shown to increase native wetland species diversity, richness, and cover in newly created wetlands compared to those that were unseeded (Reinartz and Warne 1993).

Some plant communities, such as wet prairie, are best established by seeding. For example, wetland grasses such as bluejoint (*Calamagrostis canadensis*) can be seeded on upper portions of basins that are never flooded or are not flooded until after seeds are established, or on saturated areas of basins shortly after drawdown (USAEWES 1992a). However, seeding generally is not as reliable as other methods of revegetation for newly created wetlands, because limited information about seed viability, germination, and seedling growth requirements is available to determine correct seeding rates for many wetland species (Marburger 1992). Sedges (*Carex* spp.), in particular, are not easily established from seed because germination rates are typically low and storage variables that affect seed maturation have not been determined (Bremholm 1993).

Herbaceous vegetation can be seeded using drill or broadcast methods. Seed drilling into existing vegetation is especially practical where erosion is likely if the soil were tilled or where some native species are growing at the site and additional seeding will enhance the plant community. Broadcast seeding can be used if slopes are too steep or other site conditions, such as excess moisture, do not allow no-till or grass drill use. Broadcast seeding works well for temporary grasses and annual and short-lived perennial wildflower seed. Sites should be broadcast-seeded when winds are calm. Seeded areas should be rolled with a roller or cultipacker immediately after planting to ensure proper contact of the seeds with soil (Galatowitsch and van der Valk 1994).

Seeds generally need to be planted twice as deep as the seed size. Very small seeds need to be placed just below or at the soil surface. Seeds of submerged species can be mixed with mud and dropped into the water (Marburger 1992). Recommended seeding rates are typically expressed as the number of seeds per hectare (seeds per acre) or as the number of kilograms per hectare (pounds per acre). Mixtures of grasses and forbs are generally sown at the rate of 11 kg/ha (10 lb/acre). Broadcast seeding requires application at a higher rate (as much as 22 kg/ha [20 lb/acre]) (McClain 1986). Seeding rates can also be expressed as the number of pure live seeds per hectare (acre); seeds are tested for viability for use in rate calculations. Most wetland plant suppliers can advise wetland managers about the seeding rates required for particular plant communities.

For woody vegetation, especially some bottomland oaks, direct seeding is an effective propagation method. This low-cost method allows roots to develop naturally, without disturbance caused by cutting roots and removing seedlings from nursery containers. Disadvantages are that initial forest development is slower, and this method is only reliable for large-seeded species such as oaks and hickories. Smaller seeds are susceptible to heat, dry soil, and bird and rodent predation (Allen and Kennedy 1989).

Acorns are planted 5 to 7 cm (2 to 3 inches) deep for best germination and survival. If predation is a potential problem, seeds can be planted twice as deep. Twenty-five percent of planted acorns can be expected to grow into 10-year-old trees (Allen and Kennedy 1989). These authors recommend planting 2000 to 2500 acorns per hectare (800 to 1000 per acre) if other trees are expected to become established on the site naturally, with a maximum of 3000 to 4500 acorns per hectare (1200 to 1800 per acre). The result should be 500 to 1000 trees per hectare (200 to 400 per acre) after 10 years, although some thinning may still be necessary (Allen and Kennedy 1989). Spacing for sowing 2500 acorns per hectare (1000 acorns per acre) ranges from 1.4 by 3 m (4.5 by 10 ft) to 0.9 by 4.6 m (3 by 15 ft).

4.6.6 Transplanting

Individual wetland plant sprigs from nearby wetlands or from nursery-grown stock may be the most successful type of propagule for establishing grasses and forbs in planned wetlands (Payne 1992). Sprigs are young plants that have well-developed roots and stems and are approximately 10 to 15 cm (4 to 6 inches) tall (Payne 1992). In certain instances, wetland plant sprigs may be obtained from donor wetlands that will be destroyed (see Section 4.6.3, "Planting material sources").

Another successful method of plant propagation involves producing seedlings in a greenhouse, then transferring the seedlings to shallow-water flats containing a coconut fiber substrate outside the greenhouse. Plants are allowed to grow and spread on this substrate, which has been treated with a fertilizer mix. The substrate and pre-grown plants can then be transferred and installed at the project site (USAEWES 1992a). In areas with unstable substrates, erosion mats, blankets, or pillows made of biodegradable materials (geotextiles) can be placed over the surface and the plants installed into the geotextile (see Appendix C, "Resource Materials and Sources," for examples of geotextiles available). The plants may also be planted directly into the site. Germinating seeds under controlled conditions is recommended for establishing sedges (*Carex* spp.), which often do not germinate well (Bremholm 1993).

Stem fragments of submerged species and rhizomes, tubers, rootstocks, and corms of emergent and floating-leaf species can also be transplanted into a planned wetland. If emergents are to form a border around open water, they can be planted in dense, single-species patches (Herricks *et al.* 1981). These propagules are placed directly into the substrate, anchored with clay balls or metal, or placed with several stones in cheesecloth bags and dropped at recommended water depths to prevent them from floating (Marburger 1992).

Recommended spacing for emergent transplants ranges from 0.3 to 1.5 m (1 to 5 ft) (Marburger 1992). Small propagules, such as rhizomes, rootstocks, and small sprigs are spaced more closely. If conditions at the site are unstable or subject to great physical stress or wildlife damage, dense plantings may be practical (Payne 1992). Often, several small (*e.g.,* 1.5 m^2 [16 ft^2]), same-species plantings are grouped together at appropriate locations throughout the wetland. Planting in groupings can facilitate monitoring (see Chapter 5, Section 5.5.4, "Vegetation"). This approach is also useful when predation by wildlife is a concern, because exclosures can easily be built around the plantings to protect young plants. Refer to Chapter 6, Section 6.2.7, "Mechanical techniques for wildlife control," for information about constructing various types of exclosures.

Several options exist for planting woody vegetation. Tree stock is available as bare root seedlings, containerized seedlings, stem cuttings, and as transplanted saplings or larger trees (Clewell and Lea 1990). Bare root seedlings are widely available and grow well in moist substrates when handled correctly. Seedling stems should be at least 46 cm (18 inches) long, the roots about 20 cm (8 inches) long, and the root collar (the part of the root directly below ground surface) diameter should be at least 10 mm (3/8 inch) (Allen and Kennedy 1989; Clewell and Lea 1990). They should be dormant when planted. Other planting considerations include making sure seedlings are planted immediately, or otherwise kept from dessication in a dark, cool place (1° to 4° C [34° to 39° F]) until planting, and planted only in moist soil (Allen and Kennedy 1989; Clewell and Lea 1990). Common planting mistakes that can threaten seedling survival can be avoided by planting at a depth so that root collars are directly below the ground surface, digging holes deep enough so that roots are not curved or bent, and packing soil to eliminate air spaces around seedling roots (Allen and Kennedy 1989). Recommended spacing for bare root seedlings ranges from 3 m by 3 m (10 ft by 10 ft) to 6 m by 6 m (20 ft by 20 ft) (Allen and Kennedy 1989).

Planting bare root trees in planned wetlands where soils are saturated for most of the growing season is not advised because too many fibrous roots are lost during transplanting. These roots are critical for woody species survival in anaerobic soils, and plants usually die before fibrous roots grow back (Garbisch 1994b). When containerized plants obtained from nurseries have soil/root masses smaller than the container, this indicates that the plants have not grown in the container long enough to root into the soil and will not easily become established in the wetland. Similarly, peat- or fiber-potted plants should not be used unless the plants are well rooted through the sides and bottoms of the pots (Garbisch 1994b).

Some hardwood trees such as poplars (*Populus* spp.), willows (*Salix* spp.), sycamore (*Platanus occidentalis*), green ash (*Fraxinus pennsylvanica*), and sweetgum (*Liquidambar styraciflua*) are propagated relatively easily and inexpensively

by rooted cuttings. Cuttings (whips) are 30 to 55-cm (12 to 22-inch) long sections of one-year-old twigs, 8 to 13 mm (1/4 to 1/2 inch) in diameter. Stem cuttings are harvested in the dormant season and stored in plastic bags just above freezing temperature until spring planting (Clewell and Lea 1990). In Illinois, March and April are the best months for planting. Whips are planted vertically, buds pointing up, with the top of the stem flush with the soil surface or with no more than 3 cm (1 inch) exposed. Poplar and willow whips can be planted directly at the site, whereas whips of other species grow best if pre-rooted in a nursery and then treated as bare root seedlings (Clewell and Lea 1990).

Saplings less than three years old can be transplanted from nurseries, or in limited instances, from existing forests. Trees are usually available containerized, balled and burlapped, or are tree-spaded and transported directly to the site. Using larger saplings is a more expensive method of vegetation establishment, and results at mitigation sites have been mixed. Potential problems are that roots are disturbed and sometimes lost during transplanting and that optimum growing conditions experienced in nurseries are interrupted. Consequently, saplings tend to grow slowly for the first several years, and correctly planted seedlings will be the same size as tree-spaded saplings in about 5 years (Clewell and Lea 1990).

Regardless of the planting method, planting trees and shrubs in rows is not recommended because this tends to make the site look more artificial. Instead, trees can be placed in random positions flagged for the planting crew by the wetland designer or manager (Garbisch 1994a). This will work best for sites where woody vegetation is planted by hand, and might not be practical for large sites. It may also be useful to flag newly planted trees and shrubs, especially bare roots or whips, so that they will be visible for monitoring (see Chapter 5, Section 5.5.4, "Vegetation") or management.

4.6.7 Wild hay

Another vegetation establishment method that has been suggested involves using wild hay. Wild hay has been used for prairie restoration, but its success in planned wetlands has not been documented. The procedure involves mowing an existing wetland that has a desirable plant community, and then spreading the hay over appropriate zones of the planned wetland. Wild hay should be collected during the late summer or fall when seeds of most species are ready, although mid-summer harvesting is more effective for obtaining sedge seed. Seeds from the hay will be protected during the winter and can germinate in the spring. Sedge meadow and wet prairie species are the most likely vegetation types to be established using this method (Galatowitsch and van der Valk 1994).

4.6.8 Growing conditions

The project manager must be aware of optimal conditions for plant growth. Potential problems in wetland and aquatic plant establishment can be caused by inappropriate water depths and extreme water fluctuations, nutrient deficiencies, excessive turbidity, excessive wind or current action, ice floes, unsuitable substrates, and polluted sediments (USAEWES 1993a). Compacted or heavy-textured soil (*e.g.*, clays, silty clays, and possibly silty clay loams) in planting areas can be a problem if it causes turbidity or inhibits vegetation establishment (Payne 1992).

Seeds germinate best in moist, unsaturated soils. Soil moisture may influence temperature and light interactions that trigger germination. Marsh plants often require both light and fluctuating temperatures for germination, which is an adaptation that ensures germination in shallow water where daily temperatures fluctuate as much as 10° C (18° F) (Frankland *et al.* 1987). If possible, vegetation zones in the wetland should be very moist but not inundated until plants are established. Subsequently, a gradual water level increase is needed to minimize disturbance to young plants, and water depth may need to be managed during the first one or two years to permit only short flooding periods (USAEWES 1993a).

If rainfall is not adequate in the months following planting, especially in seasonally or temporarily inundated wetlands, the area will need an additional water supply. Mobile irrigation systems, such as spray or drip irrigation, are recommended for this purpose. Alternatively, water can be supplied from water tanks mounted on trucks or pulled behind tractors. However, repeated passes across an area to provide adequate moisture increases the potential for soil compaction.

Nitrogen is often a limiting nutrient in planned wetlands because it is very soluble and can be rapidly lost from the site through drainage and percolation. It can also be transformed into gases by micro-organisms and dispersed into the atmosphere before being used by plants. Placing slow-release fertilizers in the planting hole with the plant is probably the most efficient method of application so that the nutrients will be directly accessible to the roots and rates of loss will be reduced (USAEWES 1993c). Surface fertilizer applications may promote growth of weedy species that can outcompete planted species.

Other potential problems that may limit vegetation establishment in some planned wetlands include competition from undesirable plant species and wildlife predation. Refer to Chapter 6, "Managing Wetlands," for information about remedial actions.

4.7 Post-construction site evaluation

Detailed documentation of as-built conditions in the planned wetland is essential at the completion of the project construction phase. This final site inspection is completed by the project designer or manager and resident engineer or project leader before construction equipment leaves the site. Differences between design plans and actual construction features, including location, wetland type, area, slope, hydrology, substrate, should be evaluated (Kentula *et al.* 1992). If the modifications are likely to impede achieving wetland project goals, then adjustments should be made immediately.

The project designer or manager also tests structures, piping, seals, water levels, and flow distribution (Hammer 1992). The evaluation report includes descriptions of the construction techniques used for the substrate, hydrologic features, and planting. Some construction-related problems may not appear immediately, so a "test" or "start-up" period should be established with contractors (Hammer 1992).

Additional information can be reported if it is warranted by the specified goals of the project. For some permitting agencies, as-built plans must be submitted to the agency and must include supporting materials and information as specified. Wetland managers should contact the permitting agency in their district for specific requirements.

Maps (1:1200 scale) including each wetland area (restored, created, and preserved wetland systems), buffers, and adjacent uplands should be prepared, with contours and topography provided at specified detail and intervals. Patterns of vegetation (*i.e.*, major macrophyte communities, densities, and species), open water, and major structural components should be indicated (Erwin 1991). Ground photographs, taken at permanent locations that can be used throughout the monitoring period, will support the documentation (see Chapter 5, Section 5.5.7.1, "Photographic record").

Final documentation should be filed with permanent project records so that it can be compared with future site monitoring reports (Kentula *et al.* 1992). For example, documentation concerning the final planting design (including planting arrangement, seeding rates, species planted) can be used to estimate survival rates during the monitoring period. As-built plans are used to set up an appropriate sampling scheme for each parameter included in the monitoring plan (Chapter 5, Section 5.2, "Developing a monitoring plan").

Chapter 5 Monitoring Restored and Created Wetlands—Summary

Monitoring procedures described in this chapter are used to track site establishment and ultimately to determine if project goals and objectives have been met. The monitoring process has several steps.

- A monitoring plan provides a brief statement of project goals, objectives, and performance standards, a list of which wetland components will be monitored, and a description of how each will be monitored.

- Monitoring tasks are conducted before, during, and after construction. The emphasis of this chapter is post-construction monitoring, and procedures are presented for collecting information on several components often named in performance standards:
  — soils
  — hydrogeology
  — water quality
  — vegetation
  — invertebrate wildlife
  — vertebrate wildlife
  — photographic record, structures, and weather conditions

  For each wetland component, two levels of monitoring are described:
  — Level 1 procedures direct the user to make a series of observations using steps found on field forms.
  — Level 2 procedures are used to obtain information that generally requires more time, effort, cost, and expertise to complete.

- A post-construction site evaluation is performed at the end of the monitoring period to determine whether the planned wetland project has met the performance standards, and ultimately whether the project is a success.

The cases below describe example situations in which a wetland designer or manager would use this chapter. Users should review the entire chapter. In Section 5.5, "Post-construction monitoring tasks," wetland managers should follow procedures applicable to specific components.

- **Case 1** Site assessment identifies a population of sawtooth sunflowers (*Helianthus grossesseratus*), an aggressive, native species, in the buffer area adjacent to a proposed sedge meadow. Performance standards state that the sunflower should not spread into the sedge meadow: Although the sawtooth sunflower is a native species, this population will be treated as if it were an exotic species because of its aggressive growth habit. Using procedures in Section 5.5.4.2, "Level 2 Vegetation monitoring," initiate monitoring for an exotic species prior to construction and continue throughout the post-construction monitoring period.

- **Case 2** A wetland manager is involved in planned wetland project for the monitoring phase only: Obtain pertinent information concerning the project, *i.e.*, goals and objectives, site assessment details, and design, from available documentation and individuals involved with the project. As-built plans are essential. Formulate and conduct the monitoring plan according to goals, objectives, and performance standards.

Chapter 5 Monitoring Restored and Created Wetlands

5.1 Introduction

This chapter describes how to use monitoring procedures to determine if project goals have been met. Goals were identified in Chapters 1 and 2 and transformed into design criteria in Chapter 3. Monitoring involves collecting data repeatedly over time. In planned wetlands, monitoring is essential to determine if project goals are successfully met within a specified period. Monitoring is also important in documenting the development of the planned wetland. The information obtained using qualitative and quantitative sampling of important wetland features can be reflected in management decisions (Kentula *et al.* 1992) and the wetland manager can correct problems such as inappropriate hydrology, invasion of unwanted species, and sedimentation early during wetland establishment (see also Chapter 6, "Managing Wetlands"). In addition, a monitoring plan with project goals, objectives, performance standards (criteria), and specific monitoring tasks is usually required by permitting agencies for any wetland mitigation project. The *Guidelines for Developing Wetland Mitigation Proposals* developed by the Chicago District of the U.S. Army Corps of Engineers (USACE 1993) states that, "Monitoring mitigation sites is an essential part of permit compliance determination because it generates the field data used to compare the site with pre-determined performance standards." Finally, because wetland restoration and creation is a relatively new science and practice, valuable information regarding planned wetland site

assessment, design, and construction can be obtained by carefully implementing planned monitoring programs and documenting both successes and failures. In some situations, the monitoring procedures in this chapter will be conducted in existing wetlands or potential restoration sites to establish standards or baseline information for comparison with the planned wetland or to track variation of a feature through time.

This chapter includes guidelines for developing a monitoring plan for conducting monitoring tasks before, during, and after construction, and for performing a post-monitoring site evaluation. Post-construction monitoring is emphasized, and procedures are presented for collecting information on several components, *i.e.*, soils, hydrogeology, water quality, vegetation, and wildlife. Only those components named in a specific project's performance standards need to be monitored. Keeping photographic records, maintaining structures, and considering weather conditions are also part of monitoring.

As in Chapter 2, "Site Assessment," two levels of monitoring are described for each wetland component. Each component is monitored at the particular level of detail required by the performance standards and specified in the monitoring plan.

Level 1 monitoring:

- Is used to obtain general information about planned wetland development.
- Is used when performance standards for a component are less rigorous. This level is often appropriate for first-year monitoring.
- Can be conducted by those who have a general natural resources background.

Level 2 monitoring:

- Is used to obtain more detailed information about a particular component.
- Is conducted if more rigorous information is required in performance standards.
- Generally requires more specialized training. If wetland designers or managers are unfamiliar with any suggested techniques, they should consult individuals who possess the necessary skills. Natural resources agencies are listed in Appendix B.

Evaluating planned wetlands through monitoring can identify information that will improve future design and management and can determine if the planned wetland is functioning as designed. The similarity in function and structure of planned wetlands to natural wetlands is the ultimate measure of their success. Achieving this similarity can be difficult because information concerning many types of natural wetlands often is insufficient; wetlands are dynamic systems, making comparison difficult, and meaningful assessments can take many years to complete (Galatowitsch and van der Valk 1994).

5.2 Developing a monitoring plan

A monitoring plan for a planned wetland is composed of project goals, objectives, performance standards, monitoring tasks, a remedial action plan, and a monitoring schedule. Project goals, objectives, and performance standards are explained in the planning stage of the project (see Chapter 1, "Planning Restored and Created Wetlands"). Goals may be conceptual and usually focus on a desired function for the planned wetland, while objectives generally describe particular features that must be present in the wetland in order to achieve those goals. Performance standards are threshhold values or criteria for a particular aspect of a wetland component.

Specific monitoring tasks include observation and data collection. The results will be evaluated against performance standards to determine if the planned wetland is developing as expected and if project goals will be met at the completion of the monitoring period. Ultimately, achievement of project goals defines success. If the planned wetland is not developing as intended, suggestions for remediation can be provided. A monitoring schedule outlines when each step of the monitoring plan is to be implemented. Additional information included within the monitoring plan is a list of the parties involved and their individual responsibilities, specific requirements for monitoring reports (see also Section 5.6, "Post-monitoring site evaluation"), and the length of the monitoring period.

The monitoring plan is usually written by the individual or agency that is primarily responsible for restoring or creating the wetland and for monitoring the site. If the wetland is being planned as compensation for wetland impacts, the monitoring plan will be submitted to the regulatory agency as part of a wetland compensation plan prior to project construction. All parties involved should have an opportunity to review the plan and submit comments, especially on the parts that define their involvement. See Appendix R, "Elements of a Monitoring Plan," for an example of project goals, objectives, performance standards, monitoring tasks, and monitoring methods.

The scope of post-construction monitoring can vary with the project's maturity and environmental significance, compliance requirements, and the probability of successfully achieving targeted wetland functions (Kentula *et al.* 1992). The wetland manager needs to be absolutely certain about what and how much information is needed to determine if the performance standards have been met. Insufficient data about a certain component may not provide statistically or biologically

meaningful results. On the other hand, collecting unnecessary data wastes time and money. Before initiating monitoring at a completed planned wetland project site, as-built construction documentation (see Chapter 4, Section 4.7, "Post-construction site evaluation") can be obtained from the project designer or manager to verify site conditions and set up an appropriate monitoring scheme for each component.

For most projects, monitoring will be accomplished over several years. While regulatory agencies have traditionally specified five-year monitoring periods, longer periods, *e.g.*, 10 to 15 years, are a more realistic time frame for wetland establishment (Mitsch and Wilson 1996). Site visits may be scheduled once a year or more frequently, depending on the components being measured. Recommended sampling intervals will be explained in later sections describing specific sampling methodologies.

5.3 Preconstruction monitoring tasks

Before construction, the planned wetland site will be assessed using the methods described in Chapter 2, "Site Assessment." If an historic wetland site is being restored and has some noteworthy natural quality, *i.e.*, some remnant of presettlement character, the wetland manager may decide or may be required to conduct preconstruction monitoring to provide a basis of comparison with post-construction conditions. This monitoring often focuses on vegetation, but may include soils, hydrology, wildlife habitat, or other features that play an important role at the site. For example, preconstruction monitoring would be appropriate where a drained wetland has a vegetative cover composed mainly of native plant species. A goal of this project is to increase the biological diversity of the site, measured by the increase in native wetland species that colonize after water is restored. The restoration plan calls for drainage structure removal to restore wetland hydrology. Baseline monitoring conducted prior to drainage structure removal provides a plant community description that can be compared with the restored wetland. Methods that can be used for conducting preconstruction monitoring are described in later sections of this chapter or in Chapter 2, "Site Assessment."

5.4 Monitoring tasks during construction

Monitoring during the construction period is necessary to ensure that the planned wetland is restored or constructed as designed. The primary purpose is to confirm that design specifications are followed. Activities that may result in excessive sedimentation or that involve handling of special materials such as hydric soil, donor soil, or plant material must also be carefully monitored. Proper implementation of these procedures will promote achievement of project goals. These monitoring activities are explained more fully in Chapter 4, Section 4.3, "Monitoring tasks during construction."

5.5 Post-construction monitoring tasks

The physical and chemical characteristics of a planned wetland (*i.e.*, the soils, hydrology, and water quality) are the basis for community establishment. If these characteristics do not reasonably mimic those of a natural wetland, biological aspects of the project will probably fail. Physical components are not often used as measures of planned wetland success because measures for comparisons are often unavailable. Even so, monitoring these components can provide important information that may be correlated with biological factors. Wetland biological components, *i.e.*, vegetation and wildlife, are often named in project performance standards because biological components are commonly studied as measures of wetland development. Monitoring these components can reveal deficiencies in soil, hydrology, or water quality.

Monitoring methods used within each planned wetland site should be consistent and conducted during the optimal season for a particular component so that data collected annually can be compared among years. Implementing uniform methods is also useful because it facilitates comparisons among sites.

Wetland managers should carefully document their activities during the monitoring phase. Monitoring typicially continues throughout several years and requires many site visits. Keeping accurate records regarding all aspects of the surveys promotes the consistent implementation of procedures throughout the monitoring period. This is especially important if responsibilities for the project are transferred to other personnel during the monitoring period. As-built plans may serve as a base map for site descriptions. Additional maps depicting wetland size and configuration, baseline and transect locations, photograph stations, and other important measurements or features should be drafted. A narrative description of monitoring procedures should accompany this map.

Periodic reports that describe monitoring results provide more complete documentation of project progress. A representative report might include a description of the goals, objectives, and associated performance standards; an explanation of monitoring procedures and results; a discussion of progress toward fulfilling the goals; and recommendations for remedial action when necessary. Plan sheets or aerial photographs depicting plant communities and site photographs can also be included. Funding or regulatory agencies typically request that annual or biannual reports be submitted. Managers should contact the appropriate agency concerning specific report requirements.

5.5.1 Soils

Because hydric soils characteristics typically require a long period of time to develop, soils are often not included in planned wetland monitoring. Nevertheless, wetland managers may want to monitor the development of hydric soil characteristics. The presence of hydric soils can indicate that the site has soil resources appropriate for the goals and objectives to be achieved. Soils monitoring tasks, divided into Levels 1 and 2, are analogous to assessment tasks described in Chapter 2, Section 2.2.1, "Soils."

Level 1 soils monitoring:

- Involves making general observations of soil wetness.
- Provides sufficient information about most sites for at least the first few years during the monitoring period.
- Can be performed by those with a general natural resources background.

Level 2 soils monitoring:

- Involves identifying hydric soil characteristics and performing selected soil analyses.
- May be required only at the end of the monitoring period unless problems are suspected or indicated by monitoring results of other components, or if the wetland manager desires to track hydric soil development more closely.
- Requires soil science skills.

5.5.1.1 Level 1 soils monitoring

Level 1 soil monitoring involves making site observations. Refer to Chapter 2, Section 2.2.1.1, "Level 1 soils assessment," for background information and detailed procedures for this task.

The observations made during a site visit will provide the wetland manager with enough information to comment on the development of hydric soils at the site. Hydric soil development will proceed more rapidly with prolonged saturation and an abundance of surface organic matter. Notable features include landscape position, proximity to a flood-prone body of water, and current soil wetness. Cracked soil, stunted or absent crop growth, and deep tire or foot imprints all indicate soil saturation earlier in the season. Soils that emit a strong sulfur smell (like rotting eggs) or shake (like jello) when walked upon indicate wet conditions throughout the year. Because soil and hydrologic characteristics are inseparable, the features examined overlap somewhat with hydrologic monitoring.

5.5.1.2 Level 2 soils monitoring

Level 2 monitoring that may be necessary includes hydric soil determination and analysis of soil texture, soil compaction, percent soil organic matter, and soil chemistry. Background information and procedure descriptions are contained in Chapter 2, Section 2.2.2.1, "Level 2 soils assessment."

Hydric soil determination

Features that indicate hydric soils, *e.g.,* low chroma mottling, gleying, and low redox potentials, develop relatively slowly. Therefore annual monitoring of these features, for most purposes, is not necessary. An "on-site hydric soil determination" (Environmental Laboratory 1987) is part of the jurisdictional wetland determination and delineation procedure. The project permit may require that a determination be conducted at the end of the monitoring period. Assessments of wetland hydrology and hydrophytic vegetation are also necessary parts of this procedure (refer to Sections 5.5.2, "Hydrogeology" and 5.5.4, "Vegetation").

Soil analyses

Further soils analysis, including analysis of texture, compaction, organic matter percentage, and soil chemistry, may be appropriate on a less-frequent basis and at the end of the wetland monitoring period. If possible, soil data can be collected at the same points at which the initial assessment was made in order to provide a better evaluation of change over time. If soil amendments or donor soils were not placed in the wetland during construction, soil textural analysis conducted in the assessment phase should suffice. However, if the wetland is not holding enough water because soil texture appears coarse, then soil texture should again be analyzed and steps taken to remedy the situation. Soil compaction is typically measured just prior to planting to ensure proper root development. Additional compaction measurements will not usually be necessary unless plant growth appears inhibited. Soil chemistry monitoring may be necessary for special situations such as wetland construction for waste treatment because the capacity of a soil to adsorb toxics and nutrients is influenced by its level of reduction.

5.5.2 Hydrogeology

In the post-construction monitoring phase of the wetland restoration or creation process, hydrogeologic considerations primarily consist of verifying the presence of water compared with the performance standards. For regulatory projects, the regulatory agencies may have specific requirements for both surface and subsurface water procedures, including monitoring intervals, measuring instruments, and acceptable methods. Subsurface geology, geomorphic position, and the potential presence of adequate moisture are integral parts of the assessment and design phases. If this information was not collected at these stages, the project manager can refer to the procedures outlined in Chapter 2, "Site Assessment," and Chapter 3, "Designing Restored and Created Wetlands."

Hydrogeological monitoring tasks are divided into two levels.

Level 1 hydrogeologic monitoring:

- Involves the periodic measurement of ground water and/or surface water elevation.
- Is used if the hydrogeology is relatively simple, *i.e.*, subsurface patterns of bedding (sedimentary layering) and material types are documented and continuous, a favorable geomorphic setting is present, and the presence of a reliable water source is documented.
- Can usually be accomplished by trained volunteers or nonprofessional personnel.

Level 2 hydrogeologic monitoring:

- Consists of a variety of monitoring and modeling procedures that may be necessary to verify the absence or presence of adequate hydrology for wetland maintenance.
- Is applied if the hydrogeology is relatively complex, *i.e.*, subsurface materials are poorly understood or are discontinuous in bedding and/or variable in material composition, the geomorphic position is marginal, or the potential for adequate water volume is marginal for wetland maintenance or not documented.
- Is conducted by individuals experienced in hydrogeologic data interpretation. Generally, professional hydrologists or hydrogeologists should be consulted or employed for these activities.

5.5.2.1 Level 1 hydrogeologic monitoring

Level 1 hydrogeologic monitoring generally involves measuring water level elevation in ground water observation wells or surface water staff gages on a periodic (daily, weekly, or monthly) basis. The installation of these devices and the establishment of recording procedures should be under the supervision of personnel with professional training. Procedures may be as simple as periodically digging pits to observe the level at which water pools or to observe saturation levels. Methods and installation procedures are described in Chapter 2, Section 2.2.2.2, "Level 2 hydrogeologic assessment."

Conclusions based on monitoring results depend on the performance standards and the detail in which these criteria have been stipulated. For example, if the design criteria state that surface water should be ponding to a given elevation for a stated time, then the evaluation is straightforward, *i.e.*, either water was present or it was not. If the criteria are met and no problems are evident the hydrologic aspects of monitoring are complete. However, if the criteria are not met and/or problems occur in other physically or biologically monitored characteristics, further analysis is required. The measured hydroperiod should be correlated with seasonal patterns of rainfall and temperature and analyzed for normality in abundance and seasonal pattern. If the results of this exercise suggest that the climatic activity has been within normal (1961-1990) statistical ranges, then a review and possible revision of assessment and design criteria is prudent.

5.5.2.2 Level 2 hydrogeologic monitoring

Level 2 hydrogeologic monitoring also involves the measurement of water level elevations in surface water and/or ground water situations. Problems with the presence of adequate moisture for wetland development and maintenance, however, may have been identified or expected during either the assessment and design phases or from the results of Level 1 hydrogeologic monitoring. This is generally a site-specific problem with instrumentation and procedures tailored to the site character. Monitoring of water levels may have to be done with continuously recording devices that are difficult to maintain and interpret. These results may have to be modeled to predict the outcome given certain criteria.

Generally the installation of ground water observation wells or piezometers to document the presence of subsurface water levels should be left to specialists in this field. Proper installation, matched to site hydrogeology, is critical to the collection of reliable data that can be used to answer questions concerning the presence and movement of ground water. The above data are needed to determine the site hydroperiod and construct water budgets (see Chapter 2, Section 2.2.2.2, "Level 2 hydrogeology assessment").

This information also contributes to the wetland hydrology assessment part of the procedure for jurisdictional wetland determination and delineation (Environmental Laboratory 1987). Permit conditions may require that a determination be conducted at the end of the monitoring period; assessments of hydric soils and hydrophytic vegetation are also necessary parts of this procedure (refer to Sections 5.5.1, "Soils" and 5.5.4, "Vegetation").

5.5.3 Water quality

Water quality influences the diversity of organisms found in a wetland community and also defines conditions that may be unique to an individual wetland type. The role of water quality in the biological and physical processes in wetlands is described in Chapter 2, Section 2.2.3, "Water quality." The reasons for monitoring water quality vary. A primary motivation often is to fulfill Section 404 of the Clean Water Act permitting requirements. These requirements promote general wetland protection, water quality improvement within the watershed, and quantification of important chemical parameters for comparison to water quality standards.

Two levels of water quality monitoring reflect two levels of sampling effort and the intensity of analysis needed.

Level 1 water quality monitoring:

- Involves measuring certain water quality parameters in the field.
- Is used to provide a basic water quality description.
- Can be performed by individuals who have received general training in water sampling.

Level 2 water quality monitoring:

- Involves laboratory analysis of selected nutrients and other elements or compounds.
- Is often required by regulatory agencies; can also be used when a reading of a Level 1 parameter suggests that an atypical situation may be present in the wetland or when a particular location or event suggests a potential problem. This type of information can also be collected in natural wetlands in order to develop performance standards for evaluating planned wetlands.
- Is conducted by qualified personnel. For regulatory projects, water quality analysis may need to be performed in a laboratory certified by the Illinois Environmental Protection Agency (IEPA). Contact IEPA (Appendix B, "Natural Resources Agencies") for information on lab certification.

Consistent data collection procedures are essential for obtaining comparable results in water quality analyses. In this discussion, a water "sample" is the amount of water collected at a specific location to measure and analyze a given set of parameters. The frequency and number of samples taken within a wetland or potential planned wetland site will vary among individual projects, depending on particular wetland features, project goals, and objectives. During the first year following wetland construction, water might be sampled every six to eight weeks to evaluate both Level 1 and Level 2 water chemistry parameters. After the first year, the sampling design should be re-evaluated and, if frequent fluctuations are not detected during the first year, data may be collected quarterly during the remainder of the monitoring period. For regulatory projects, changes in sampling frequency are subject to regulatory agency approval.

Considerations regarding water quality sampling and the equipment required are discussed more thoroughly in Chapter 2, Section 2.2.3, "Water quality." Additional guidelines for sampling specific parameters are provided within the discussion for each. A useful field reference is the *Pocket Sampling Guide for Operators of Small Water Systems: Phases II and V* (see Appendix H, "Field Guides"). More complete procedures are explained in *Compilation of E.P.A.'s Sampling and Analysis Methods* (Keith 1992).

Results obtained from a Level 1 or Level 2 analysis can be compared over time for the same wetland, or among wetlands within a single complex to clarify water flow and pollutant flow patterns. Results can also be compared with published or accepted water quality standards, if available, which may be included as a performance criterion for the permit issued for a wetland mitigation project. General use standards are designed to protect water for aquatic life, wildlife, agricultural use secondary contact, and to ensure the aesthetic quality of the aquatic environment. These standards are applied to waters that have no specific designation (IEPA 1995). Mitsch and Gosselink (1994) and Stevens and Vanbianchi (1993) also list ranges for certain wetland types.

5.5.3.1 Level 1 water quality monitoring

Level 1 monitoring includes measurement of the water quality parameters pH, temperature, conductivity, and redox potential (ORP). Refer to Chapter 2, Section 2.2.3.1, "Level 1 water quality assessment" for background information and detailed procedures for obtaining these measurements.

5.5.3.2 Level 2 water quality monitoring

Level 2 monitoring includes sampling for parameters that are not easily measurable in the field. These parameters include the common forms of carbon, nitrogen, phosphorus as well as the major anions and cations, total alkalinity, total dissolved solids, and trace elements. They are listed in Chapter 2, Table 2-3. Some of these nutrients or pollutants are markers for point or nonpoint pollutants (Simon and Cahill 1994). Trace organic compounds may occasionally be important to analyze in the laboratory from field-collected water. These trace organic compounds include pesticides, polyaromatic hydrocarbons (PHC), and polychlorinated biphenyls (PCB). Background information and detailed sampling procedures are discussed in Chapter 2, Section 2.2.3.2, "Level 2 water quality assessment."

5.5.4 Vegetation

Vegetation change in a planned wetland is an excellent indicator of wetland change or development. Vegetation monitoring is often considered the most important gauge of wetland development and is monitored at nearly every project site. If baseline (preconstruction) vegetation characterization of a potential restored wetland site was described as part of the assessment phase, these results can be very useful for later comparisons. Monitoring may also be initiated at a created wetland site after the construction phase is completed. Refer to Appendix H for a list of field guides and resource materials. Vegetation monitoring tasks are divided into two categories and are similar to assessment tasks in Chapter 2, Section 2.2.4, "Vegetation."

Level 1 vegetation monitoring:

- Employs qualitative methods to describe general characteristics and features of plant communities.
- Is used when the vegetation is easily described. It may be appropriate for first-year monitoring if only sparse vegetation is present.
- Is designed for a user who has basic plant identification skills.

Level 2 vegetation monitoring:

- Employs both qualitative and quantitative methods to provide more detailed plant community descriptions.
- Is useful when performance standards are more rigorous for aspects of vegetation or if the wetland manager desires to track vegetation development more closely.
- Requires greater botanical and/or statistical knowledge.

5.5.4.1 Level 1 vegetation monitoring

The monitoring tasks described below include vegetative cover type mapping, compilation of species lists and assignment of abundance values, determination of dominants, and determination of percent predominance of hydrophytic vegetation. Depending on the purpose of monitoring, one or any combination of these methods may be appropriate. Background information and detailed procedures for each of these tasks are provided in Chapter 2 (Section 2.2.4.1, "Level 1 vegetation assessment").

Vegetation cover type mapping

Cover type mapping onto aerial photography is a relatively simple way to document change in plant community boundaries. Vegetation cover types are described in Appendix E. In the monitoring context, cover type mapping is most appropriate when overall change in plant community size and configuration must be evaluated over time. A project goal of establishing a certain percentage of a cover type(s) requires cover type mapping to determine whether this can be achieved.

High-quality aerial photography taken annually at a scale that shows important vegetation features is necessary for accurate mapping. Scales ranging from 1:1200 [1 cm = 12 m (1 inch = 100 ft)] to 1:4800 [1 cm = 48 m (1 inch = 400 ft)] are the most appropriate. As in any cover typing effort, the detail of the plant community labeling and delineation will depend on project goals and objectives and the photography characteristics. For example, an objective may be to create 50% emergent wetland. To determine emergent wetland area, all types of emergent wetland present, such as cattail marsh, sedge meadow, and reed canary grass wet meadow, can be merged into one cover type. If the project objective is to create 25% sedge meadow and 50% cattail marsh, then cover type mapping should further distinguish emergent wetland types. These detailed vegetation cover types can be subdivided from the basic list of cover types. Mapping techniques and level of detail should remain consistent for the extent of the project, if feasible.

Compilation of species lists and assignment of abundance values

Compile species lists and assign abundance ratings. These activities are conducted during the growing season at approximately the same time each year. Plant community composition and the relative abundances of various species of the plant community can then be compared over time.

Determination of dominant vegetation

A procedure for determining dominant vegetation at a wetland site is included in the "routine on-site wetland determination method" used in the jurisdictional wetland delineation process (Environmental Laboratory 1987). This method is useful for long-term monitoring because it provides a relatively simple way to estimate dominant vegetation for each stratum and for the community as a whole. Monitoring is conducted during the growing season because vegetation of all strata, including herbaceous, is examined.

Because only gross estimates of coverage are defined, this method only detects relatively large changes in plant species composition over time. It is employed most appropriately where species composition change is expected to be relatively large. The method should not be used in planned wetlands where subtle changes are expected or need to be monitored to assess progress toward project goals.

Determination of percent predominance of hydrophytic vegetation

This method can be used for monitoring the change in hydrophytic vegetation at a site over time. Annual determination of plant community dominants coupled with the assignment of wetland indicator status to each species will result in a yearly assessment of the development and stability of wetland vegetation. This procedure can be used to assess hydrophytic vegetation development in distinct community units as defined by vegetation type, water regime, or management method.

This assessment method is also applied as part of the procedure for jurisdictional wetland determination and delineation (Environmental Laboratory 1987). Permit conditions may require a determination to be conducted at the end of the monitoring period; assessments of hydric soils and wetland hydrology are also necessary parts of this procedure (refer to Sections 5.5.1, "Soils" and 5.5.2, "Hydrogeology").

5.5.4.2 Level 2 vegetation monitoring

The two approaches described in Level 2 vegetation monitoring are quantitative sampling and the floristic quality assessment. Quantitative sampling provides the most useful information on a long-term basis, while the floristic quality assessment is a qualitative method. Wetland managers may wish to conduct one or both of these techniques. In addition, monitoring may be necessary for rare and exotic species. Background information and detailed procedures for these tasks are described in Chapter 2, Section 2.2.4.2, "Level 2 vegetation assessment."

Quantitative sampling

Planned wetland projects may require a quantitative vegetation sampling program to determine whether the goals of the project are being achieved. Although quantitative, statistically defensible data analysis requires a greater time investment, it is a tool the wetland manager can use to identify subtle changes or problems within the plant community that may not be noticeable during a single site visit. Therefore, this approach is the most meaningful in the long term. Information collected over several years can also help reveal the best management options (see Chapter 6), chart the progression of restoration, and identify trends in desirable or problem species assemblages.

Vegetation sampling is usually conducted to obtain information about species richness, frequency, density, and dominance (cover) of the plant communities at planned wetlands. Refer to Appendix I, "Quantitative Vegetation Sampling," for further explanation of these terms and detailed procedures. Additional references on using quantitative sampling in wetlands are Magee *et al.* (1993), Stevens and Vanbianchi (1993), Horner and Raedeke (1989), and Kentula *et al.*(1992).

Before initiating quantitative sampling, the special conditions of planned wetlands must be considered. Many wetland soils are easily disturbed by foot traffic, especially if paths for sampling transects are traveled regularly. Areas that are especially susceptible to disturbance include newly-created wetlands with young and unstable soils and high-quality wetlands such as fens, seeps, and bogs, whose soils remain saturated nearly all year. To lessen disturbance in wetland areas, sampling is best done during a dry phase of the growing season.

Floristic quality assessment

The floristic quality assessment (FQA) described by Swink and Wilhelm (1994) and further developed by Taft *et al.* (1996) may be useful for characterizing the floristic integrity of the site. The FQA may be required by some regulatory agencies for wetland compensation projects. A floristic quality index (FQI) is calculated from the number and floristic values, or coefficients of conservatism, of the species present at the site. This assessment should be conducted only during the growing season. Detailed procedures for this method and its limitations are described in Appendix K, "Floristic Quality Assessment."

The FQA can be applied to long-term monitoring of natural quality and monitoring habitat restoration (Swink and Wilhelm 1994). Monitoring floristic quality throughout several years is typically designed to answer the following questions: 1) What is the overall site floristic quality; 2) Is the floristic quality evenly distributed over the site; and, 3) Do management practices, such as prescribed burning, brush cutting, exotic species weeding, or "hands-off" management affect floristic quality? An annual inventory of plants growing at the site or within subdivided vegetation cover types within the site, and the subsequent calculation of the FQI and mean conservatism coefficient may reveal answers to these questions during the early establishment stages of a wetland. Further explanation of these uses is provided in Swink and Wilhelm (1994). After the wetland plant community has become established, quantitative data will need to be combined with the FQI in order to track important changes in abundance patterns (see "Quantitative sampling," above, and Appendix I).

Rare species

A rare plant species, including species listed as threatened or endangered in the state of Illinois or at the federal level, occasionally may occur within a project site. The chance that a rare plant species will occur in a created wetland where major landscape alterations are made is highly unlikely. However, rare species may occur at a restored wetland site, depending on the condition of the site previous to restoration activities, or in a high quality buffer area. During the monitoring phase, the site should be repeatedly visited and carefully sampled to determine if a change in population characteristics occurred over time. If endangered species management is a project objective, population monitoring can help determine if the desired results are attained.

Rare species, by their nature, are difficult to sample by conventional quantitative sampling methods. If conventional methods would be apt to miss the population entirely, then more directly targeted sampling methods must be used. The amount of effort spent searching for a rare plant population during the monitoring phase depends on project goals. If the project goal is to maintain an intact population after a restored wetland is established, then a simple annual census may be adequate. If the project goal is to determine the exact change in population size, vigor, or reproductive stage throughout the monitoring phase, more specific methods of describing the population are needed. Permanent plots can be installed at the beginning of the monitoring period to facilitate long-term sampling of a plant population. If detailed sampling is conducted, care should be taken to replicate the sampling effort

and season in subsequent years. Detailed procedures for monitoring rare plant species are found in Appendix L. Refer to Goldsmith (1991) for further discussion of rare plant monitoring.

If rare species are located or introduced into planned wetlands, report the occurrence or introduction to the Endangered Species Protection Board (Appendix B, "Natural Resources Agencies").

Exotic species

Exotic plants are not native to the flora of the region in which they are found. They may have been accidentally or purposefully introduced into North America from Asia or Europe (Illinois Nature Preserves Commission 1990). To follow the spread or demise of an exotic plant species at a site, or to evaluate the success of an exotic plant species management program requires the design and implementation of a monitoring program to quantify the changes. The most important project goal involving many exotic species is eradication. If effort is spent on monitoring alone, the exotic species could spread throughout the project site and cause a much greater problem. Research and monitoring is essential to document effects of exotics, determine the effects of management, and develop effective management methods (Hester 1991).

Exotic species are similar to rare species in that they may grow and spread from patchy populations. Therefore, methods and guidelines for asessing exotic species are similar to those used to assess rare species. Conventional sampling methods may miss a population entirely, and methods that directly target the species must be used. Methods are discussed in Appendix M, " Exotic Species Assessment and Monitoring."

5.5.5 Invertebrate wildlife

Invertebrates are an important part of freshwater wetland systems because they provide food for other marsh wildlife, break down organic matter, and contribute to the diversity of the wetland (Murkin and Wrubeleski 1988; Ross and Murkin 1989). The invertebrate community reflects wetland type and successional stage (Weller 1986). This section applies primarily to macroinvertebrates, or those that can be seen with the naked eye, including adult and immature insects, crustaceans, worms, and snails. A general invertebrate identification guide is *Ecology and Classification of North American Freshwater Invertebrates* (Thorp and Covich 1991).

Reasons for monitoring invertebrate populations generally include a need to evaluate the wetland's ability to perform the functions of food chain support and ecosystem diversity (Horner and Raedeke 1989). If invertebrates are considered an important component of a planned wetland project, inventory data can be collected as a part of the assessment phase and subsequent sampling throughout the monitoring phase of the project could identify important changes. Invertebrate population trends in turn can be linked to waterfowl and fish population trends and can be used to complement water quality monitoring. Specific species may be important in some planned wetland projects. For example, a planned wetland site may contain habitat similar to a nearby wetland that supports a threatened, endangered, or rare invertebrate species. Sampling for that species at the natural and planned wetland provides important information about the potential colonization of the new wetland. Because data collection and analysis are generally more labor intensive, invertebrate monitoring is not often included in performance standards or required by regulatory agencies.

Two levels of invertebrate wildlife monitoring are described.

Level 1 invertebrate monitoring:

- Consists of a qualitative assessment of the organisms present.
- Provides information about general invertebrate population trends within the wetland over time or among wetland sites.
- Can be performed by those who have some experience with macroinvertebrate taxonomy.

Level 2 invertebrate monitoring:

- Involves identifying invertebrates to more specific groups.
- Is used to reveal greater insight into trends within or among wetlands.
- Requires greater expertise with macroinvertebrates.

Many macroinvertebrate sampling techniques are available, and they are often habitat specific. In wetlands, invertebrates inhabit the air above the wetland (usually adult insects that have emerged from the aquatic environment or that use the wetland for foraging), the water surface, the water column, the vegetation (on or in vegetation, above or below the water surface), or the substrate. Flying insects are sampled with sweep nets or black light traps, and emerging adult insects with emergence traps. Invertebrates on the water surface are usually sampled with dip nets while invertebrates in the water column are sampled with activity traps or water column samplers. Invertebrates associated with vegetation are sampled with sweep nets (above water), dip nets (under water), or by vegetation removal (on and within vegetation). Invertebrates in the substrate are sampled with dip nets, dredges, or core samplers. Merritt *et al.* (1984) list a variety of qualitative and quantitative samplers for wetlands, and Downing (1984) also describes a variety of sampling devices.

Four common samplers are dip nets, activity traps, emergence traps, and artificial substrates. Dip nets can quickly sample a large area, but are not appropriate for quantitative sampling (Horner and Raedeke 1989). Activity traps provide a population measure of free-swimming invertebrates (Ross and Murkin 1989). Emergence traps capture the emerging adults of aquatic insect larvae (Davies 1984). Artificial substrates provide a standard area for colonization and collection of wetland invertebrates.

As with all monitoring programs, consistency in sampling design and implementation is essential to produce results that allow for meaningful comparisons over the monitoring period. Ambient conditions (temperature, time of day, cloud cover, wind), sampling effort, habitat similarity, and seasonal timing should be kept as uniform as possible. Seasonal progression can be gauged by calculating degree days from local weather data obtained from the Illinois State Water Survey (see Appendix C, "Resource Materials and Sources;" refer also to Section 5.5.7.4, "Weather conditions"). The seasonal and life history requirements of the species of interest must be considered to determine the optimal time for data collection.

5.5.5.1 Level 1 invertebrate wildlife monitoring

In many monitored wetland sites, invertebrates are simply counted or identified to order or family because species identification may be extremely difficult. Individuals can be further sorted into trophic levels (predators, herbivores, detritivores) (Ross and Murkin 1989). This abundance data can profide information about general trends and may indicate habitat changes. Individuals per sampling unit (sampling area or effort) can be calculated and the totals can be compared (Horner and Raedeke 1989). All four common samplers listed above are appropriate for Level 1 sampling.

5.5.5.2 Level 2 invertebrate wildlife monitoring

Identification to genus or species level can provide greater insight into trends within a planned wetland. Some insect groups that are important in wetlands and relatively easy to identify are dragonflies, caddisflies, horse flies, deer flies (Pechuman *et al.* 1983), and mosquitoes (Ross and Horsfall 1965). Dragonfly adults can be monitored by simple observation and larvae can be sampled using standard or modified dip nets (Cashatt *et al.* 1992). Caddisflies, horse flies, and deer flies are sampled with emergence traps, and mosquitoe larvae are sampled with dip nets.

5.5.6 Vertebrate wildlife

Providing wildlife habitat for terrestrial vertebrates is often a planned wetland project goal, and objectives may target a particular species. Monitoring for general habitat features or specific species or species groups can be an important part of a monitoring plan. Refer to Appendix H for a list of field guides and resource materials.

Level 1 vertebrate monitoring:

- Is used to describe wildlife habitat features of a wetland.
- Is used when a general description or indicator of habitat is needed.
- Requires familiarity with wetland characteristics and some ability to recognize vertebrate species in the field.

Level 2 vertebrate monitoring:

- Involves conducting surveys or censuses for each group of interest, *e.g.*, amphibians, reptiles, small mammals.
- Is performed when it is necessary to follow a specific species or group of vertebrates over a given time period.
- Requires more expertise in species recognition for a given group. Experts may be consulted for identification aid (see Appendix B, "Natural Resources Agencies").

5.5.6.1 Level 1 vertebrate wildlife monitoring

The following discussion corresponds to field form "Level 1 Wildlife Assessment," (Appendix G), a quick, simple procedure that evaluates several criteria that indicate a wetland's relative suitability as wildlife habitat.[1*] This form is designed for use when wetland assessments are being performed and is described more thoroughly in Chapter 2, Section 2.2.5.1, "Level 1 wildlife assessment." If the procedure is applied annually at a planned wetland and comparisons are made between years, it can become a part of a monitoring program at a site. The procedure provides a general estimate of a wetland's overall wildlife diversity. Wetlands with high scores are likely to provide habitat for threatened or endangered species, and the wetland manager should refer to Level 2 monitoring methods regarding field surveys for the appropriate species. As an alternative to this method, wetland managers may prefer to use the Habitat Evaluation Procedure (HEP) (USFWS 1980) for one or more species of interest.

The 12 criteria used to assess wetlands are dominant wetland class, number of wetland classes, wetland size, landscape position, surrounding land use, dispersal corridors, food resources, hydroperiod, percent open water, water/vegetation interspersion, special habitat features, and wildlife observations. Scores for an individual criterion or groups of criteria can be compared over time. The project goals may indicate that certain criteria are more important than others for a specific planned wetland and these criteria could be evaluated separately.

1 * The field form was developed by Patti L. Malmborg, William C. Handel, and Joyce E. Hofmann and is based on experience in Illinois wetlands, but has not been rigorously tested.

5.5.6.2 Level 2 vertebrate wildlife monitoring
Assessment methods described in Chapter 2, Section 2.2.5.2, "Level 2 wildlife assessment," can be applied to monitor amphibians, reptiles, birds, and mammals. Because data will be collected throughout the monitoring period in most cases, sampling methods, effort, and timing must be replicated for all years. Consistency is necessary if meaningful comparisons are expected. Techniques used depend on the taxonomic group being studied; some require specialized equipment such as traps or drift fences, and can be labor intensive and/or time consuming. The use of methods that involve capturing and handling animals may require personnel conducting the assessment to obtain a scientific permit from the IDNR Division of Wildlife Resources (see Appendix B, "Natural Resources Agencies").

Amphibians and reptiles
Before these techniques are implemented, the wetland manager must become aware of the specific activity patterns of the individually monitored species. For many amphibian and reptile species, appropriate sampling time periods can be very limited, and sampling outside of these narrow windows would be meaningless. Consult relevant printed information about species and experts in the field before developing any sampling plan.

The two most common methods for both inventory and monitoring studies are visual encounter surveys (VES) and audio surveys. In a VES, field personnel wade or walk through an area searching for animals for a set amount of time, or person-hours. This type of study is used to compile a species list for an area and to determine relative abundances of species present, but is not appropriate to determine densities. It can be performed in an aquatic or terrestrial habitat. In aquatic habitats, searching for individuals can include the use of seines, nets, and hands. In terrestrial habitats, searching includes turning over rocks and logs. A VES can be performed within a marsh, floodplain forest, or other wetland type; searching patterns can be random or follow a prescribed quadrat design, using a zigzag or grid pattern, or transects. Important information to record about the site is the date, location, searching pattern, weather conditions, air temperature, time spent on survey, and habitat description. Information to record about the located individuals is the species name, sex, substrate, location, activity, and time (Heyer *et al.* 1994).

The other important type of sampling is an audio survey, which uses the calls of reproductive male frogs and toads to estimate or determine relative abundances of calling males, relative abundances of all adults, species composition, and breeding habitat use. All calling frogs and toads along a transect or at a census point are recorded as present and counted (Heyer *et al.* 1994). Audio cassette tapes of frog and toad calls are available (see Appendix H, "Field Guides").

Measures to standardize sampling efforts such as keeping track of person-hours spent searching and attempting to replicate the date and time of sampling from year to year are essential to produce census results that can be compared. Seasonal factors such as precipitation, temperature, and seasonal progression (measured by degree days or soil temperatures at 20 cm [8 inches]) should be as consistent as possible.

Birds
Birds are important to census as part of a long-term monitoring program because they are excellent indicators of habitat quality, generally abundant, readily observed, and popular with the general public (Horner and Raedeke 1989). Presence of species, population size, breeding success, and survival rates can be measured (Goldsmith 1991). The monitoring effort can be simplified by concentrating on a target species (*e.g.*, a threatened or endangered species), instead of monitoring the total bird community, if establishing habitat for the particular species was a project goal (Ryder 1986; Galatowitsch and van der Valk 1994). Because birds are so popular with the general public, local conservation groups may volunteer to participate in very simple surveys (Galatowitsch and van der Valk 1994).

Sampling methods vary depending on the type of birds sampled and on the habitat in which they are found. Procedures for conducting surveys are found in Ralph and Scott (1981), Horner and Raedeke (1989), and Goldsmith (1991). Before conducting a census, the wetland manager should consult detailed sources and knowledgeable individuals (see Appendix B, "Natural Resources Agencies").

Primary census methods include point counts, strip transects, spot mapping, nest searches, and aerial surveys. Point counts are the simplest to conduct for the greatest variety of birds in a variety of habitats and involve establishing census points around the perimeter of the wetland, at discrete locations within the wetland, or along transects through the wetland. The number of individuals of each species seen or heard during a given time period at each point is recorded. Strip or line transects can be conducted throughout the year and involve counting all birds on each or one side of the transect. Spot mapping can only be conducted during the breeding season, is very labor intensive, and provides an estimate of the number and locations of breeding pairs within a definite area (Goldsmith 1991). Nest searches are conducted by traversing the wetland in a zig-zag pattern, flushing birds, and locating nests (Galatowitsch and van der Valk 1994). These searches are most appropriate for wet prairies, sedge meadows, and emergent marsh zones. However, nest searches are extremely disruptive to birds breeding in the wetland and therefore should be used only with extreme care in limited circumstances. Aerial surveys are most appropriate for counting migratory and

nesting waterfowl, shorebirds, and colonial waterbirds (Connors 1986; Eng 1986; Speich 1986). Identifying species can be difficult from the air; therefore, aerial surveys may only provide an overall number of birds using a specific wetland.

Season, time of day, sampling period, and sampling effort for bird surveys should be consistent throughout the monitoring phase of the project. Censusing during inclement weather (rain and wind), or within earshot or eyesight of highways or any other overriding distractions should be minimized. Whereas point count surveys can be conducted during any season, breeding bird surveys may be most meaningful and can only be completed during the breeding season, usually April through July in Illinois. Secretive birds (*e.g.,* Virginia rail, sora, American and least bittern) can be censused by playing recordings of their calls at the census points. Taped recordings can also aid the census of some hawks and owls. Recordings can also be very disruptive and should be used only under the direction of professionals.

Mammals

Mammals differ greatly in size and behavior and a combination of methods is needed to inventory or monitor the entire mammalian assemblage in an area. Methods for conducting mammal surveys are described in Davis (1982) and Cooperrider *et al.* (1986). Small mammals (*i.e.*, some rodents and insectivores) can be inventoried and censused with snap traps, pitfall traps, or live traps. Snap traps or live traps can be placed in lines or grids; pitfalls can be arranged in grids or associated with drift fences. Trapping results can be expressed as relative abundance of each species (number of individuals/number of trap-nights x 100). Larger species of mammals (*e.g.,* lagomorphs, carnivores, and ungulates) are usually detected by direct observation or the presence of sign rather than by trapping. Aerial surveys, roadside counts, counts of sign, flushing counts, and scent-station surveys can be used to estimate the relative abundance of larger mammals. Specialized techniques needed for bat inventories are described in Cross (1986) and Kunz (1988). The presence of bats can be determined by visual observation, supplemented with the use of a bat detector. Species identification usually requires capturing animals and bats are very difficult to census.

Standardized procedures are important for monitoring mammals. Censuses need to be performed during the same season for each year of the monitoring period so that population estimates will be comparable. Within the appropriate season, censuses should be conducted when environmental conditions are favorable for observation or capture (*e.g.,* small mammal activity may be inhibited by bright moonlight).

5.5.7 Additional monitoring tasks

5.5.7.1 Photographic record

Photographs taken periodically throughout the monitoring period from permanent locations within and surrounding the planned wetland can document plant community changes and development. Locations can be marked with metal posts and indicated on the plan sheet or aerial photograph (Horner and Raedeke 1989). Sampling points can be selected in conjunction with transects and vegetation sampling points, and a sampling pole can be placed in the photograph to document height (Stevens and Vanbianchi 1993). Photograph station number, compass bearing, photograph frame number, date, and time should be recorded (Horner and Raedeke 1989). If the camera has a zoom lens, the lens needs to be set at the same length (typically, 50 mm) for all photographs taken throughout the monitoring period.

5.5.7.2 Structures

During monitoring site visits erosion control and hydraulic structures within the planned wetland should also be inspected to determine if they are functioning properly. Failure of erosion control devices can result in rill and gully formation and sedimentation into the wetland. Water control structures should be maintaining the designed water levels. If problems are detected, corrective measures should be implemented as necessary.

5.5.7.3 Weather conditions

Weather conditions such as precipitation, temperature, cloud cover, and wind can affect the outcome of most types of monitoring. For example, heavy rain can affect the results of water chemistry analysis and strong winds and rain can affect the activity of most animals, especially birds and flying insects. If possible, conduct monitoring for a given wetland component under similar ambient conditions each year. Conditions should be recorded for each date during the site survey. When survey data are analyzed, differences among sampling dates occasionally may be at least partially explained by fluctuations in weather.

For more site-specific weather data, a weather station can be established at the site. The station can be monitored frequently (more than once per week) to collect the weather data. A less precise but easier way to obtain at least regional weather data is through the National Weather Service. The Service maintains 200 weather stations throughout Illinois, recording temperature and precipitation data daily. This information is available to the public for a small fee through the Illinois State Water Survey and the National Climatic Data Center. A lag period of approximately six months can be expected for both sources because of the processing time necessary to receive the data from the National Weather Service. Addresses and phone numbers for the two sources are listed in Appendix C, "Resource Materials and Sources."

5.6 Post-monitoring site evaluation

The post-monitoring evaluation determines whether the planned wetland project has achieved the stated goals. Evaluation is based on the documented development of the site throughout the monitoring period. Monitoring results should be compared to performance standards. If the data show that the performance standards are met by the end of the monitoring period, the wetland is considered to have achieved project goals and is therefore regarded a success.

If one or more wetland components do not meet performance standards, then the individual, organization, or regulatory agency responsible for monitoring must determine how to proceed. Although all criteria may not be met in some wetlands, data may show a trend toward accomplishment. In this situation, monitoring may be extended on an annual or less-frequent basis to verify progress. Similarly, floodplain forests probably will not be established by the end of the typical five-year monitoring period, and therefore the sites should be visited during several year intervals for approximately 10 additional years.

A final report on the planned wetland should be prepared and submitted to the appropriate agency, according to specific requirements. The report may contain a description of the project site (including site and location); background information about the project history (site assessments, botanical and zoological surveys, monitoring plans, etc.); results of the initial site assessment if relevant, wetland determinations, previous year(s) monitoring, and as-built surveys; important site visits and agency involvement; and results of the current year's monitoring. Supplementary material to the report may include analyses for each wetland component for individual years, complete species lists for all sites at the project area, and the photographic record.

Chapter 6 Managing Wetlands—Summary

This chapter presents guidelines and methods for developing an effective management strategy.

- Management objectives link management methods with wetland functions.

- The following management methods used to correct problems or inadequacies and promote achievement of long-term goals are discussed:
  — silt management
  — water level manipulation
  — mechanical techniques for vegetation control
  — fire
  — chemical controls
  — biological controls
  — mechanical techniques for wildlife control
  — habitat enhancement
  — managing human use

- Management schedules can be used to prioritize tasks and carry them out more efficiently and effectively.

- Potential participants in the various facets of wetland management include professionals, landowners, and volunteers.

The cases below describe example situations in which a wetland designer or manager would use this chapter. For all projects, users should follow the guidelines and procedures in Sections 6.1, "Management objectives," 6.3, "Management schedules," and 6.4, "Potential participants." The wetland manager should refer to Section 6.2 for methods applicable to particular management objectives.

• **Case 1** A forested, planned wetland site supports many weedy, emergent wetland plants while trees are becoming established:
As long as trees show significant growth, the best management strategy is to allow the plant community to develop without intervention. Trees will eventually develop a canopy, and shade-tolerant plants will outcompete those adapted to more open communities.

• **Case 2** A population of muskrats known from a marsh located nearby is expected to move into the planned emergent wetland site:
The management plan should include means for protecting young plant material from predation. Refer to Section 6.2.7, "Mechanical techniques for wildlife control," for suggested methods.

• **Case 3** Purple loosestrife becomes established at the planned wetland site soon after the conclusion of monitoring:
The individual, agency, or organization responsible for maintaining the wetland should remove the invasive species as soon as possible. Refer to Section 6.2.5, "Chemical controls," and Section 6.2.6, "Biological controls," for suggested strategies.

Chapter 6
Managing Wetlands

Wetland management means both wetland manipulation and basin protection. Historically, wetland management has meant wetland drainage, an attempt to "reclaim" wetlands for human uses, or less frequently, wetland manipulation for hunting and fishing (Mitsch and Gosselink 1993). In this guide, we define wetland management as active involvement to manipulate (or to choose not to manipulate) a feature of a natural or planned wetland to sustain restoration or creation project goals and objectives.

Management objectives are directly related to project goals and objectives established in Chapter 1, "Planning Restored and Created Wetlands." The methods used to accomplish management objectives will correct problems or inadequacies identified through the monitoring process in the short-term and promote achievement of long-term goals after the monitoring period is over. This chapter first reviews possible objectives for management activities. Then a variety of management methods for silt, vegetation, wildlife, and human use are discussed. Management schedules and potential participants are also considered.

When a management program is designed for a wetland site, the most important concept to keep in mind is that the management methods should mimic or enhance the processes similar to those that formed presettlement wetland communities and that now would occur naturally to maintain ecosystem integrity, stability, structure, dynamics, and species diversity. If ecological processes are lost or replaced by artificial processes, the structure and diversity within natural communities and ecosystems can be lost as well (Illinois Nature Preserves Commission 1990).

The natural processes affecting wetland vegetation, soils, and hydrology include fire, ice action, herbivory, and water-level changes caused by flooding or drought (Payne 1992). Using natural processes and forces in management will most likely produce more natural conditions. Many times, using these techniques will cost less and be most successful (Weller 1994).

Wetlands are dynamic systems that experience many changes over time, even when unaffected by human intervention (Hammer 1992). Because this is usually a slow process, the new system may require active management to promote development of the desired successional (developmental) stage. However, natural cycles may need to be manipulated if the goals for a wetland specify that a particular successional stage be maintained.

Any management practice designed to enhance conditions for one or a group of species inevitably will contribute to the demise of other species. This management paradox applies to decisions that all natural areas managers must make (Harty 1991). The importance of formulating clear and nonconflicting goals early in the planned wetland design process and then tying management practices directly to these goals cannot be overstated.

6.1 Management objectives

Management activities can help ensure that a certain function develops at a project site. Planned wetland goals are expressed primarily in terms of function. Objectives may be expressed in terms of wetland type, land management, or target species, for example. These functions are described in Chapter 1, Table 1-1, and include flood flow alteration, sediment stabilization, sediment and toxicant removal, nutrient removal and transformation, production export, ground water recharge and discharge, biological diversity and abundance, recreation and aesthetics, and natural heritage (Adamus *et al.* 1987; Marble 1992).

The following section links functions that are addressed in this guide with management methods described in later sections of this chapter. Certain features of each function are considered most important to maintain that function. In this chapter, we will discuss the important features of each function that can be addressed by site management. These features are drawn from Marble (1992).

6.1.1 Flood flow alteration

Management that encourages the growth of dense vegetation cover increases the ability of a wetland to perform this function because a greater plant density slows water moving through a wetland and enables the wetland to store water for a longer time. More vegetation relative to open water will slow water more effectively. If high flooding levels are expected, managing for the development of woody vegetation that rises above the flood level will also detain water in the wetland longer. Frictional resistance against flood waters can be increased by the the strategic placement of boulders and logs. If water control structures are in place regulating the amount of water into and out of the wetland, they can be manipulated to allow for the greatest duration and amount of water storage.

6.1.2 Sediment stabilization

Sediment and shoreline stabilization are enhanced by the presence of dense vegetation. Management that encourages the development of dense vegetation, especially persistent emergent and woody vegetation types, is desirable. If water control devices regulate water input to the wetland, these can be manipulated to encourage sheet flow into the wetland, rather than more erosive channel flow. Vegetated shorelines will anchor exposed soils with plant roots; wider vegetated borders will lessen the amount of erosion.

6.1.3 Sediment and toxicant removal

Management of water control devices to hold water within the wetland will result in slower water movement through the wetland and more deposition of sediments and toxicants. If water flow can be managed so that it is shallow, frictional resistance and slower water velocity will result. Dense wetland vegetation also aids in slowing water velocity, retaining water longer in the wetland, and discouraging the resuspension of bottom sediments. Maintaining dense vegetation in upland buffers will minimize soil erosion and reduce the amount of sediment-laden water entering the wetland.

6.1.4 Nutrient removal and transformation

Management that encourages the detention of water in the wetland will result in more efficiency of this function. If water control devices are used, adjusting them for maximum water detention will slow down water velocity and lengthen detention time. Dense vegetation will also favor increased frictional resistance and slow water flow, resulting in an increase in the wetland's ability to remove and take up nutrients.

6.1.5 Production export

Management that encourages dense, especially herbaceous, vegetation contributes to the achievement of this function. A variety of vegetation strata will promote balanced production export rates throughout the year. Maintaining hemi-marsh conditions will result in the most productive configuration. If water flow can be controlled, the site should be managed for seasonal flooding; dry periods will encourage decomposition and wet periods will encourage the export of decomposed matter. If possible, sheet flow rather than channel flow should be encouraged because sheet flow increases contact between plants and water, resulting in higher production export.

6.1.6 Ground water recharge

If a wetland has been restored or created to provide ground water recharge, the hydrogeolgic setting, hydraulics, and water movement into and through the site will have been accounted for in the design. Project maintenance primarily involves monitoring land use practices so that water quality does not deteriorate.

6.1.7 Biological diversity and abundance

Management for biological diversity and abundance primarily involves vegetation. The following vegetation and basin features, listed with the expected result or clarification following in parentheses, can affect certain aspects of diversity and abundance: water/vegetation proportions and interspersion (higher bird diversities are associated with relatively even proportions of water and vegetation); vegetation class richness and interspersion (various vegetation cover types and classes are required to meet different life stage needs and provide greater diversity of cover for animals); richness of waterfowl food plants (preferred plants should occupy at least 10% of the wetland); outlet characteristics (permanent outlet ensures that toxins do not accumulate in the wetland); upland/wetland edge (irregular edge between wetland and upland improves breeding, migration, and wintering habitat); and special upland habitat features (nearby plants provide nesting, feeding, or cover sites).

6.1.8 Recreation and aesthetics

Maintenance of any structures or developments at the site, such as trails, boundary markers, fences, and interpretive signs and periodic site surveillance will help ensure the achievement of this function. Removing undesirable plant species by weeding, brushcutting, or burning, replacing planted showy species that fail to become established, and controlling nuisance animals such as carp and geese can also improve the aesthetic appeal of a site.

6.1.9 Natural heritage

Management that promotes natural habitat diversity, the establishment of regionally uncommon habitat types, and increased habitat for plants and animals that are listed as endangered or threatened at the state or federal level helps achieve this function.

6.2 Management methods

Methods discussed in this section are commonly used to achieve project goals and objectives. We suggest specific applications of these methods to common wetland management situations. Managers may need to combine several methods to accomplish the desired outcome. Valuable resources for managers include the *Vegetation Management Handbook* (INPC 1990) and the *Compendium on Exotic Species* (Natural Areas Association 1992), which discuss specific control methods for numerous plant species, and the *Wildlife Management Techniques Manual* (Schemnitz 1980), a resource for wildlife and habitat-related concerns.

6.2.1 Silt management

Siltation can lower the overall quality of created or restored wetlands. Refer to Chapter 3, Section 3.3.2, "Sediment stabilization," to determine the proper design concepts that minimize sediment flow into wetlands. Because wetlands lie downslope from upland areas, they are collection points for many different water-borne substances, including sediment and associated toxic substances. Slope stabilization, the use of buffer areas and erosion barriers, silt fencing, and runoff diversion from the wetland site all contribute to maintaining the water quality in the wetland. If excess sediment does accumulate in the wetland, it may need to be removed.

6.2.1.1 Slope and shoreline stabilization

A planned wetland's shoreline can be susceptible to such damage as erosion from waves and run-off and slumping of the slope into the wetland if undercut. In most cases, these problems can be alleviated by proper site design. Some problems may develop from other unforseen reasons such as changes in surrounding land use.

If erosion becomes a problem at a shoreline, several remedial measures can be taken. If the shoreline slope is too steep, one option is to grade it to a more gradual slope. Another method to minimize erosion from the water's force against the shoreline is to install a snow fencing barrier to protect the shoreline from wave action (Holmes and Stalling 1987).

Many restoration specialists are developing useful methods for stabilizing shorelines and establishing vegetation in highly erodible areas by using biodegradable geotextiles, such as erosion mats, logs, and pillows (USAEWES 1992a). See Appendix C, "Resource Materials and Sources," for supplier information.

6.2.1.2 Buffer areas

Managing the surrounding upland buffer areas can provide nesting cover for wildlife and reduce soil erosion, predation of wetland wildlife, and chemical and fertilizer pollution (Wenzel 1992). Buffers should be inspected annually for the development of erosion channels, the invasion of undesirable plant species, or other potential problems. If such problems develop, corrective actions can be taken quickly. These actions should be based on the stated goals for the buffer areas, and could include the installation of erosion barriers or the removal of a problem species. Activities to avoid include excessive use of fertilizers, insecticides, and herbicides, and any activities that disturb the development of the intended vegetation (Welsch 1991).

6.2.1.3 Erosion barriers

Silt fencing, hay bales, cover crops, mulch, erosion mats, and temporary sediment ponds can be used to minimize erosion and the flow of pollutant- or sediment-laden water entering a wetland (Eggers 1992). These materials and techniques will need to be monitored periodically to determine if they are contributing to the desired outcome. Refer to Chapter 5, Section 5.2.7.2, "Structures," for information on how to conduct monitoring of erosion control structures.

If erosion barriers are not functioning as intended, remedial measures must be taken. Collapsed silt fencing and dislocated hay bales, mulch, and erosion mats need to be repositioned or replaced. Cover crops should be replanted if they did not become established as intended. Water may not be flowing into and out of temporary sediment ponds as intended, and the pond, with its associated input and output channels, may need to be redesigned to achieve the original objectives for water flow.

6.2.1.4 Removing excess sediment accumulation

If excessive amounts of sediment have accumulated in the planned wetland despite erosion control, a corrective measure such as sediment removal may be necessary. Dredging can be done using mechanical or hydraulic machines. The wetland may be dewatered before dredging, or sediments can be removed from beneath standing water. A silt fence curtain can be placed downstream from the dredge to contain the turbid water created by the operation (Payne 1992). Dredging the bottom of an established planned wetland, however, has drastic ecological effects. Along with the removal of unwanted sediment, established vegetation and seed banks are removed (Mitsch and Gosselink 1993), as well as benthic organisms. Removal of the substrate and vegetation has negative effects on any established wildlife. Therefore dredging is recommended only as a last resort.

6.2.2 Water level manipulation

Water level modifications are frequently used by wetland managers to maintain specific plant communities for specific wetland functions (Marburger 1992). Water level management in a wetland can be modeled after the natural cycles that exist in undisturbed wetland areas. These areas are subject to water level fluctuations on an annual or otherwise regular basis, and many of the biological processes that occur there are dependent on these fluctuations (Weller 1978; Weller 1994). The natural drawdown and reflooding cycle helps maintain the productivity of wetlands by allowing the recycling of nutrients (USDA-SCS 1992a). Various water levels can be achieved naturally under weather conditions favorable to the desired outcome, but water control structures, used singly or in combination, usually must be in place to enable the wetland manager to manipulate the levels in a restored or created wetland. Chapter 3, "Designing Restored and Created Wetlands," describes the utilization of hydraulic structures such as dikes, levees, embankments, stoplogs, and drop inlet pipes.

6.2.2.1 Dewatering of a wetland, or drawdown

Drawdown is the process of reducing water levels in a marsh to mimic the natural drying periods that may occur in a marsh on a cyclic basis. The primary management objectives for implementing drawdowns are to encourage the re-establishment of herbaceous vegetation removed by muskrat grazing, high water levels, carp damage, winter kill, plant disease, or any other cause; to control weedy native or exotic plant species; and to control nuisance animals such as muskrats and carp. Drawdown can help create or re-establish hemi-marsh conditions in an open water system to attract wetland birds (Payne 1992; Weller 1994), and also encourage some aggressive natives such as smartweed and barnyard grass, which provide wildlife food. Most planned wetlands will require water level manipulation during the vegetation establishment stage (Hammer 1992).

Wetland managers can apply different drawdown schedules in specific wetlands to determine the best approach to accomplish desired results. The *Engineering Field Handbook* Chapter 13, "Wetland Restoration, Enhancement or Creation" (USDA-SCS 1992a) provides detailed information on drawdown. Drawdown timing, duration, speed, and depth of flooding influence plant species composition and consequently, the associated animal life. Other factors that influence species composition are soil moisture, seed bank content, and management activities such as disking and plowing once the area is dewatered (USDA-SCS 1992a). In general, slow drawdowns in the early spring or over the winter encourage the most diverse plant communities, and are the most commonly conducted. Early drawdowns (before mid-June) promote establishment of vegetation cover and will probably allow development of perennial rhizomes capable of surviving the following winter. Later drawdowns (July and August) result in reduced cover and may not allow seed production in the current year (Weller 1978; USDA-SCS 1992a). Flooding the following year also will determine the long-term outcome of the drawdown effort. Flooding in the year following an early season drawdown can be deeper because the vegetation has had a longer period of time to develop, whereas flooding following a late drawdown should be shallow to prevent an extensive vegetation die-off (Merendino *et al.* 1990; Merendino and Smith 1991). The *Engineering Field Handbook* Chapter 13 details the advantages of varying speed and season for drawdown (USDA-SCS 1992a).

Growing season drawdown is used primarily to encourage wetland plant development. Complete drawdowns allow wetland plant seeds to germinate and water-stressed emergents

to recover. Partial drawdowns are used when vegetation is sparse but not entirely killed and wildlife use has declined. Water levels are reduced to shallow depths to encourage vegetative growth of emergent plants and germination of submergents. As vegetation recovers, continued regulation of water levels will allow nesting and plant consumption by herbivores (Weller 1990, 1994). The site is reflooded gradually to avoid disturbing plants that are just becoming established.

Drawdown can also be used to control some exotic plant species and weedy natives. Beule (1979) found that two years of partial drawdown, followed by one year of complete drawdown and drying of peat soils, reduced the cattail (*Typha* spp.) population by 50%. This type of water level manipulation, however, is generally not very effective for cattail control unless soil in the root zone drains thoroughly for at least two years (Beule 1979; Knighton 1985). In fact, drawdown may result in a greater problem with cattail if soils remain moist throughout the period because cattail seeds germinate on exposed, saturated soils (Bedish 1967; Hammer 1992). Hammer (1992) found that in an area heavily infested with purple loosestrife (*Lythrum salicaria*), drawdown in the early part of the growing season resulted in explosive growth of the loosestrife, and recommended late summer drawdown if loosestrife is a potential problem.

Complete drawdown can also be used to discourage certain pest animals, such as muskrats and carp. Late autumn drawdown will reduce muskrat populations and conserve vegetation (Weller 1994). Carp reproduction can be reduced by a drawdown initiated after spawning which usually occurs during May or June; this action will strand eggs and fry in temporary pools where predation rates can be very high. Drawdowns conducted during hot weather also effectively kill carp because oxygen concentrations drop in any remaining pools. Winter drawdown after freezing will also kill carp (Payne 1992; Weller 1994). If carp can survive in small pools of water; care must be taken to ensure that all fish are killed before reflooding the wetland (USDA-SCS 1992a).

Various pipe sizes and configurations, including anti-beaver enclosures, can be placed in beaver dams or artificial berms to achieve desired water levels (Buech 1985; Clemson University 1992; Hammer 1992; Payne 1992; Hammerson 1994). For example, one device that is suitable for areas fed by small streams or springs is the Clemson Pond Leveler. The leveler is designed with a submerged intake so that water levels can be manipulated without the beavers detecting the source of water loss (Clemson University 1992). Refer to Appendix C, "Resource Materials and Sources," for more information about this device.

Flooding, regular drawdown, elimination of stagnant waters, and removal of floating duckweed mats (*Lemna* spp. and *Spirodela* spp.) can also help minimize floodwater mosquito problems (Hammer 1992).

6.2.2.2 Flooding, or inundation

Flooding can occur as a result of precipitation cycles, beaver activity, or manipulation of water control structures. Flooding is often recommended for control of both woody and herbaceous exotics or weedy native plant species.

If water tables have been artificially lowered, restoring water levels to historical levels often controls glossy buckthorn (*Rhamnus frangula*) (Heidorn 1991). Large water table fluctuations had a suppressive effect on stem growth of willow and cottonwood, with spreading rates highest when the water table was steady throughout the year (Harrington 1986).

Reed canary grass (*Phalaris arundinacea*) cannot tolerate extended flooding (Apfelbaum and Sams 1987). Water depth should be at least 30 cm (1 ft); reed canary grass has been documented to persist after flooding at a depth of 45 to 60 cm (18 to 24 inches) for two years, but to die out in the third year (Eggers 1992).

Another application of inundation for vegetation involves cutting, mowing, or disking the undesirable plants at water or ground level. This action is followed by flooding to a level above the cut surface, effectively drowning the plants. Refer to Section 6.2.3, "Mechanical techniques for vegetation control," for more about this application.

Beavers often create wetlands by damming streams to form ponds. By manipulating the water levels, beaver ponds can be maintained as wet meadows, shallow marshes, or deep marshes (Payne 1992) and can provide favorable habitat for wildlife that depend on ponds, pond edges, or dead trees (Hammerson 1994). Within the area of beaver influence, a manager can allow several ponds at various stages to occur for the differing needs of wildlife (Yoakum *et al.* 1980).

6.2.3 Mechanical techniques for vegetation control

Disking, mowing, cutting, and digging unwanted plants are labor-intensive, but sometimes worthwhile methods of eliminating or managing a problem species. Physical removal alone can eradicate some species, but plant parts such as rhizomes usually remain in the soil to resprout and perpetuate the problem (Stevens and Vanbianchi 1993). Therefore, these methods are usually employed in combination with other control measures. Vegetation can be cut and covered with mulch materials (including road felt, or clear and black plastic) or water, for example (Boone *et al.* 1988; Dobberteen *et al.* 1989; Stevens and Vanbianchi 1993).

Removing invasive shrubs from a restoration site may pose a management paradox for wetland managers. Rapid elimination of these shrubs may negatively affect nesting habitat for many native songbirds. Whelan and Dilger (1992) have suggested that exotic or weedy shrub removal be conducted over an extended period. First, about one half of the unwanted shrubs are removed, focusing on seed-bearing

individuals. Native shrubs can then be planted within the cleared areas and other natural gaps. As the shrub plantings mature and begin to provide nesting habitat, the remainder of the weedy shrubs are removed. This approach can be followed for all types of shrub removal and subsequent restoration.

Disking, mowing, and cutting are all stem removal methods that have been used to control woody vegetation. Disking willow (*Salix* spp.) and cottonwood (*Populus deltoides*) seedlings in dry, hot weather will control the species' growth and spread, and will help maintain a site in an early successional stage. Disking two to three times per year every two to three years will achieve this goal (USDA-SCS 1992a).

Willow and cottonwood can also be controlled by mowing followed by shallow flooding; autumn mowing followed by winter flooding is usually the most successful. The water level must cover the tops of the cut stumps to ensure complete kill. In a field experiment in Wisconsin, Harrington (1986) found that cutting stems in a willow clone increased new shoot emergence and growth. Significantly more resprouting occurred on cut stems which were also severed from underground stems than on cut stems that still had intact connections below ground. This suggests that exisitng stems may suppress new stem growth.

Cutting of resprouts and girdling larger stems of glossy buckthorn are effective control measures when prescribed burns are not practical (Heidorn 1991). Cut stems should be treated immediately with herbicide.

In general, herbaceous vegetation is cut near the ground surface in late summer when carbohydrate reserves are low. This action can be followed with either naturally or artificially induced inundation to a level above the cut stem (Beule 1979; Stevens and Vanbianchi 1993). One type of floating equipment designed for cutting vegetation and rhizomes to create open water is the "cookie cutter," which consists of a boat equipped with two rotary and propelling blades (Payne 1992). Rhizome removal is followed by inundation (Stevens and Vanbianchi 1993). The cookie cutter is especially useful for removal of cattail. Cutting of cattail stems and then flooding to a depth of at least 7.5 cm (3 inches) is also a reliable control method (Nelson and Dietz 1966). Cutting can be completed in the winter when the wetland is flooded and soils are stable, if deeper water conditions in spring are expected (Weller 1994). Cutting of cattail can also be done during the late summer or early autumn, if deeper water is expected over winter. If cattails are cut during the growing season, cutting should be timed so that root reserves are at their lowest (mid-summer after flowering is complete) and should be followed by flooding (Nelson and Dietz 1966; Beule 1979; Payne 1992).

Early detection of a purple loosestrife infestation and subsequent monitoring are extremely important if control is desired with the measures presently available. Judging the stand's age and density will help predict the potential of the seed bank to contribute to the severity of the infestation. If a loosestrife stand is located in the planned wetland, the rate of its spread should be determined. Areas within the planned wetland site that are susceptible to new populations can be identified. When a new population is detected, young plants should be removed as soon as possible. If fewer than 100 plants are present, hand pulling is possible. The above-ground plant parts and as much root as possible should be bagged on site and removed for later disposal (Stevens and Vanbianchi 1993). Because purple loosestrife spreads so easily from the copious amounts of seed that it produces, wetland site managers can easily and unknowingly transfer seed from an infested site to other areas. Boots, pant cuffs, and field equipment should be inspected and cleaned after leaving an infested site to prevent seed transfer (Eggers 1992). If a population is detected that is too widespread to be eradicated, available money and effort can be directed toward keeping loosestrife out of the highest quality areas (Heidorn and Anderson 1991).

Cutting and removing stems or cutting seed heads of reed canary grass have not been very effective because seeds and rhizomes left in the soil re-establish the stand (Apfelbaum and Sams 1987; Stevens and Vanbianchi 1993). Moderate control can be achieved by cutting and covering the cut area with a mulch such as road felt, although this method is not feasible for a large area (Stevens and Vanbianchi 1993). Covering with black plastic for two growing seasons after cutting resulted in a reduction in the population, although some individuals persisted (Apfelbaum and Sams 1987). Researchers in Wisconsin found that correctly-timed mowing accomplished two objectives: controlling reed canary grass by removing immature seed and exposing the ground to light, which promoted native wetland species growth (Gillespie and Murn 1992).

Mechanical methods that have been studied for common reed (*Phragmites australis*) include cutting and covering with clear plastic, which resulted in an initial 5% survivorship (Furbish and Bratton 1987); cutting for 2 to 3 successive years in August or September, which reduced the density for 8 to 10 years; using a "cookie cutter" or rotary ditch digger to create openings in thick rhizome substrate on wet sites; and using a bulldozer, brush cutter, disk, mower, rototiller, plow, crusher, or dredge to create openings on dry sites (Payne 1992). However, Garbisch (1986) claims that successful common reed control is not feasible, and that mowing, plowing, disking, and burning all facilitate the spread of the grass.

Under certain management programs, muskrat populations may be used to promote hemi-marsh conditions, beneficial to many nesting birds (Bishop *et al.* 1979). Openings cut by muskrats in dense vegetation, for example, encourage the nesting of yellow-headed blackbirds, a species listed as threatened in Illinois (Herkert 1992; Weller 1994). Large

muskrat populations, however, can decimate emergent vegetation in a marsh (known as muskrat "eat-outs"), thereby reducing habitat for waterfowl and other wildlife (Bishop *et al.* 1979). Open water conditions may persist for many years, with long-term affects on wildlife (Weller 1990).

6.2.4 *Fire*

As with any other management method, fire aids some species and promotes the achievement of some goals while harming other species and reversing progress toward other goals. Prescribed fire can be conducted for a number of reasons: to control invasive species (Stevens and Vanbianchi 1993); to reduce organic matter accumulations; to influence insect and mammal populations; to increase food sources for geese and waterfowl; to create deep water openings in peat marshes; to shape plant community composition by favoring grasses over forbs; and to slow or reverse marsh succession (Weller 1990; Hammer 1992). Both prescribed and wild fires can have harmful effects as well, including reducing vegetation cover for wildlife, reducing forb cover by favoring grasses, destroying areas of peat accumulation (Weller 1990), and by actually destroying individual animals (Harty 1991). By causing these changes, fire can substantially alter the system's hydrology and biology (Hammer 1992). The timing of prescribed burns plays an important role in achieving a certain desired outcome (Payne 1992). Prescribed burns in Illinois are conducted in the autumn or spring, often because of specific management goals or practicality. Detailed explanations of burning techniques and strategies are described in McClain (1986), Payne (1992), and Pauly (1988).

Prescribed burns can be especially useful for managing aggressive native and non-native species. Fire will kill seedlings and larger stems of glossy buckthorn but must be used on an annual or biennial basis for five to six years or longer to effectively control established stands (Heidorn 1991). Burning followed by flooding exerts good control for cattail (Payne 1992). For reed canary grass control, fire has been used with mixed results. Hutchison (1992) reports that annual late autumn or late spring burning can curtail the invasion and spread of the species, but five to six years may be needed before satisfactory control is evident. He also found that burning was most effective when other native species were present in the seed bank so that a native plant community could develop. Burning is not very effective in dense monocultures where native species are not present. Late spring burns may weaken a stand and prevent seed formation but also suppress competitors such as native spring blooming species (Apfelbaum and Sams 1987; Henderson 1990). In an unpublished study in northeastern Illinois, burning a reed canary grass meadow resulted in the re-establishment of sedge meadow vegetation. The most effective time for burning is just before flowering or during flowering. A higher wind velocity and thicker thatch are needed to carry the fire during the growing season (Steven I. Apfelbaum, pers. comm.). Wetland managers should always account for effects to wildlife when considering growing-season prescribed burns.

6.2.5 *Chemical controls*

6.2.5.1 Repellents

During early wetland establishment stages, repellents such as soap or commercially available chemical formulations may deter some grazing by wild animals (Stevens and Vanbianchi 1993). Commercial deer repellents can be applied at the base of trees to protect the trees from beaver damage or on rags tied to a line strung along an old dam to discourage dam reconstruction (Hammĕrson 1994). Hanging small bags of human hair around the perimeter of the site may temporarily discourage deer from intruding.

6.2.5.2 Pesticides

Pesticides useful for addressing management concerns include herbicides and insecticides. Managers planning to apply pesticides in a wetland should obtain an Illinois pesticide applicator license and become familiar with their application. Guidelines for pesticide application (including herbicides) are described in the *Illinois Pesticide Applicator Training Manual* (Nixon *et al.* 1992). Those planning to apply herbicides in wetlands should obtain permits for applying herbicides in both aquatic and noncrop use areas. Contact the Illinois Department of Agriculture Bureau of Environmental Programs (see Appendix B, "Natural Resources Agencies") for information about herbicide application permit procedures.

Users should exercise discretion in making the decision to employ herbicides. Herbicides should be used in wetlands and open water habitats to control or eliminate unwanted native or exotic plant species **only** when the use of other natural or mechanical methods is not feasible. Wetlands are subject to pesticide regulations for either aquatic and noncrop upland habitats, depending on whether standing water is present or not. The *Illinois Urban Pest Control Handbook* (Nixon 1994) includes chapters on herbicides for aquatic environments as well as rights-of-way, industrial, and other noncrop areas.

Several factors will influence the decision to apply chemicals. The main benefit of herbicide use is the efficiency with which they help control large scale vegetation management problems. Herbicide use reduces labor costs, saves time, and covers large areas quickly. In addition to the difficulties related to nonselectivity, however, herbicides have other application challenges. Control gained with a one-time application may be short-term; in most cases repeated treatments are necessary as the seed bank germinates or as resprouting occurs (Eggers 1992; Hammer 1992; Stevens and Vanbianchi 1993).

Herbicides can be either nonselective (killing both broadleaf [forbs] and graminoid [grasses, sedges, rushes, etc.] plants) or selective (killing only broadleaf or graminoid plants). Nonselective herbicides are effective for spot treatments of target species but should not be used for area-wide application unless total kill is acceptable. Glyphosate is a nonselective herbicide commonly sold by the trade names Rodeo (for use over open water) and Roundup (for use over dry land) (Stevens and Vanbianchi 1993). A herbicide that selectively kills broadleaf weeds is extremely useful when attemping to control some pests because damage to surrounding graminoid plants that are common in wetlands is minimized, although other nontarget broadleaf plants could be damaged. The broadleaf herbicide 2,4-D is approved for use in aquatic habitats; it is sold under various trade names. Garlon 3A, a broadleaf herbicide, is being tested for wetlands but has not yet been approved (Eggers 1992). Garlon 4 is a new formulation that controls woody vegetation with basal bark treatment completed at any time during the year and can be used in wetlands during dry periods when no open water is present (DowElanco, pers. comm.).

Herbicides can be applied as foliar sprays, foliar wicks, stump treatments, and basal bark applications. Foliar sprays are spread with a hand-held pump sprayer or a backpack sprayer for smaller areas or where fine control of the spray is required. Larger areas can be treated with a sprayer mounted on a tractor or truck. Herbicide can be wicked onto foliage for finer control of material. Wicks that include a herbicide-saturated sponge, with an attached pint or quart herbicide "tank" are available (see Appendix C, "Resource Materials and Sources," for supplier information). A homemade wick can be produced by placing a sponge measuring about 2.5 by 2.5 by 5.0 cm (1 by 1 by 2 inches) inside a nylon stocking and attaching the stocking to a spray wand with a rubber band or twist tie. A hole for the end of the spray wand is bored into the sponge (Robert Szafoni, IDNR, pers. comm.). For woody vegetation treatment, herbicide can be applied to the stump immediately after cutting or as a basal bark application. Red food coloring or dye can be added to the herbicide mix to mark treated stumps. The chemical concentration differs for each method; check the label for each formulation. Basal bark treatments can be applied with a wick or sprayer. Managers should refer to the herbicide label for information about recommendations and safety guidelines.

Application timing must match the susceptible growth stage for the target plants; annuals, biennials, perennials, and woody vegetation vary regarding the optimal time for maximum control. In general, herbaceous plants are the most susceptible to herbicide when plants are young and actively growing, before flowering has begun. Many exotic species "green up" before native vegetation does in the spring; this phenology allows for the spraying of target plant species before desired plants are susceptible (Payne 1992). The season for applying herbicide treatment to woody vegetation depends on the method used. The best seasons for stump treatment are spring and autumn, when sap is flowing, but foliage is nearly absent. Less foliage also makes the job of cutting and hauling branches much easier. Basal bark treatment can be applied during any season.

Heavy equipment should not be used to apply herbicides because fragile soils found in wetlands can be seriously damaged and desired plant communities disturbed. Large-volume equipment can, however, be useful when positioned along the wetland perimeter and equipped with a long hose that reaches the infested areas. Chemicals should be applied carefully so that the herbicide does not drift to adjacent land (USDA-SCS 1992a). Off-site spraying may inadvertently affect a wetland site by herbicide entering in surface water runoff, and, in turn, may have adverse effects on the wetland plant community composition (Weller 1994).

Herbicides are useful for a variety of exotic and weedy native species. Beule (1979) tested the potency of Amitrol T, Radapon, and Dowpon against cattail, and determined that certain concentrations produced a kill that lasted three years. For a large area, herbicides can be applied using an all-terrain vehicle during dry periods or a helicopter.

Herbicide use is the most effective control method currently available for extensive infestations of purple loosestrife. Glyphosate herbicides (Rodeo over water, Roundup over land) have resulted in the best control, although they kill both grasses and forbs. The optimal time for herbicide application is in late summer before seed has fully developed and dispersed. Herbicides can be applied to infested areas with a hand-held sprayer, through aerial application, or with a wiper/wick applicator (Monsanto Company, unpublished). To prevent reestablishment after spraying, seed heads should be removed before the plants are sprayed. A follow-up spray can control resprouts, but repeated sprays may become necessary as seeds in the seed bank germinate at different rates. Careful application of a glyphosate will limit the spray to the target plant species, if desired non-target species are interspersed with the loosestrife. This approach will enable the desired species to recolonize the area vacated by the dying loosestrife. In localized infested areas, spraying should begin from the outside and proceed over time to the center of the infestation. This will enable desired species growing on the infestation's periphery to colonize the sprayed areas (Notestein 1987; Larson 1989; Heidorn and Anderson 1991; Payne 1993; Stevens and Vanbianchi 1993). Spraying may be required on an annual basis for several years until the seed bank is exhausted (Eggers 1992).

The herbicide Rodeo, when used for reed canary grass control, is best applied in early spring when it is green and most

native wetland species are still dormant (Hutchison 1992). Another herbicide treatment may need to follow the initial application when the reed canary grass that has sprouted from seed has reached 15 to 30 cm (6 to 12 inches). After this second treatment, native species can be planted at the site (Eggers 1992).

The most reliable methods for controlling common reed involve the use of a herbicide. Most authors agree that use of a glyphosate (*e.g.*, Rodeo) is necessary for any degree of control (Garbisch 1986; Payne 1992). Herbicide should be applied at least annually at the time of or just following flowering; better eradication may be obtained with two applications per year, or by spraying annually for a few years. Spraying is often followed by a prescribed burn to reduce the standing biomass (Garbisch 1986; Payne 1992).

Mosquitoes are an inevitable component of most freshwater wetlands in the temperate zone, but populations can be reduced. In Illinois, the most common mosquitos are the inland floodwater mosquito (*Aedes vexans*), the dark rice-field mosquito (*Psorophora columbiae*), and the northern house mosquito (*Culex pipiens*). The inland floodwater mosquito breeds in areas subject to flooding. The dark rice-field mosquito develops in temporary pools, roadside ditches, shallow depressions, and in animal and wheel tracks that fill with water after rains. The northern house mosquito develops in overgrown ponds, stagnant and shaded pools, poorly managed waste-effluent lagoons, catch basins, bird baths, and plugged roof gutters (Nixon 1993; Illinois Department of Public Health 1994). The inland floodwater mosquito is the most common mosquito found in wetlands throughout the state. Information regarding the identification of Illinois mosquitoes is described in a technical publication (Ross and Horsefall 1965).

Insecticide use may be necessary in some situations. Unless outbreaks become severe, control opportunities for the northern house mosquito are limited because of the diversity and isolation of breeding sites (P. Nixon, Illinois Natural History Survey, pers. comm.). Because this mosquito can carry the encephalitis virus, populations are monitored by the Illinois Department of Public Health. If outbreaks become severe, aerial spraying of adult populations is implemented. Suggestions regarding repellants and insecticides for mosquito control are available in the *Illinois Urban Pest Control Handbook* (Nixon 1994), *Management Guidelines for Illinois Nature Preserves: Mosquito Control* (INPC 1991), and from local Cooperative Extension offices. For problems with carp, fish-killing chemicals, such as Rotenone, are an extreme but effective control method if used in conjunction with fish barriers to prevent carp from re-entering the treated area (Payne 1992).

6.2.6 Biological controls

Classical biological control of vegetation involves introducing carefully-screened insect pests, usually from the exotic plant species' area of origin. In general, prospective insect pests are collected and then evaluated regarding their ability to suppress the problem plant species and to survive and reproduce in the relocation climate (Hight and Drea 1991; Thompson 1991; Malecki *et al.* 1993). Biological control is not yet widely practiced in wetlands in Illinois, but is being used on a trial basis for purple loosestrife control in selected areas of the state.

The greatest potential for long-term purple loosestrife control lies with the development of a successful biological control program. This type of control would be permanent, effective, relatively inexpensive, environmentally safe, widespread, and would require minimal human effort (Hight and Drea 1991; Thompson 1991). Two species of leaf-eating beetles were first released into sites in northeastern Illinois in 1994 to evaluate their effects on purple loosestrife stands, and a root-feeding weevil was released in 1995. In 1996, leaf-eating beetles were released at 30 sites, and root weevil eggs were inoculated into purple loosestrife stems at several of the sites (Voegtlin and Wiedenmann 1996).

For mosquitoes, biological controls such as the bacterial insecticides *Bacillus thuringiensis israeliensis* (best for *Aedes* mosquito larvae) and the presence of adult mosquito predators such as bats and swallows can provide some relief (Hammer 1992; Mitsch and Gosselink 1993).

6.2.7 Mechanical techniques for wildlife control

6.2.7.1 Fencing

In recently planted sites, large numbers of waterfowl can damage young plants, and exclusion of birds may be necessary (Bartoldus *et al.* 1994). Waterfowl can damage new plantings by uprooting the tubers and feeding on above-ground vegetation. Because geese normally need open water for landing, grazing pressure can be reduced or even eliminated if emergent zones are not bordered by large areas of open water (Garbisch 1986). If the establishment of extensive open water areas is an essential component of the planned wetland design, and if vegetation in an adjacent emergent zone is suffering from grazing by geese, then deterrents or barriers can be constructed to prevent geese from landing on open water or from gaining access to plantings. Large flags set throughout the planted area may deter geese from landing. However, geese may adjust to the presence of the flags after a short time and enter the area, and other types of exclusion will be necessary.

Various exclusion devices constructed from monofilament fishline, chicken wire, and wooden stakes, including "goose-grids," "goose grazing-barriers," and "varmint barriers," have been developed, and some are available commercially (see Appendix C, "Resource Materials and Sources," for supplier

information). "Goose-grids" are made by stretching monofilament fishline across open water areas in a grid having approximately 6 by 6 m (20 by 20 ft) units, which are small enough to prevent geese from taking off after landing. "Goose grazing-barriers" exclude geese from moving into the emergent vegetation zone to feed after landing in open water. Wooden stakes set at 1.8-m (6-ft) intervals support 1/8-inch nylon line spaced every 15 cm (6 inches) vertically from a point 15 cm (6 inches) above the low water mark to 15 cm (6 inches) above the high water mark (Garbisch 1986). "Varmint barriers" consist of chicken wire fencing placed in 0.6 m (2 ft) of water along an open water/emergent vegetation zone interface to keep pest species out. Exclusion is more effectively initiated prior to nesting in mid-spring (LaFayette Home Nursery, Inc. 1991a). In all cases, plastic flagging or aluminum foil strips should be attached to the line to increase its visibility. The use of an exclosure fence is recommended to protect vegetation until plants develop a thick root mat, which may take two to three years (Garbisch and Garbisch 1994). If the area has potential for supporting other wetland birds, the manager should carefully observe if any barriers have detrimental effects on those birds.

Muskrats cause special problems for the establishment of wetland vegetation because they find freshly-planted succulent tubers very attractive food (Weller 1990) that is easily uprooted. If muskrats remain in the wetland, a physical barrier placed between the plants and the muskrats may become necessary. Wire exclosures can be placed around the planted area; wire mesh, measuring approximately 1.5 cm (5/8 inch) by 2.2 cm (3/4 inch), should be mounted on 0.9 m (3 ft) wooden stakes (Eggers 1992). "Varmint barriers" can be used in combination with "goose-grids" and "goose-grazing barriers" to offer additional protection (LaFayette Home Nursery, Inc. 1991a). Roots and tubers of new wetland plantings may be susceptible to beaver feeding as well. The plantings can be protected from this damage by chicken wire or hardware cloth or with a "varmint-barrier" (Hammer 1992; Stevens and Vanbianchi 1993).

Deer can cause damage primarily to woody vegetation in wetlands. A general guideline for minimizing herbivore pressure at a planned wetland site is to locate the site near areas that provide suitable forage, thus minimizing the relative attractiveness of forage at the site. If this is not possible, wire or translucent plastic tubes will protect woody plantings from deer browse. In limited situations, if herbivory pressure from deer becomes intense, fencing may be an option. Fence height must be at least 2.4 m (8 ft) to be effective; electric fences have also successfully excluded deer. Yoakum *et al.* (1980) describe specifications for building fences for excluding wildlife. Mechanical protection of tree bark from beaver damage can be accomplished by covering the trunks with chicken wire or hardware cloth (Stevens and Vanbianchi 1993; Hammerson 1994).

Livestock grazing has been used to reduce vegetation in marshes. Beneficial grazing levels have been difficult to determine, however, and overall, grazing is often far more detrimental than beneficial. Livestock grazing often damages wetland vegetation and soils, especially in the early stages of establishment (Hammer 1992). Grazing and trampling from livestock can discourage nesting birds by reducing their nesting cover, may destroy the nests and young of ground-nesting animals, can decrease the plant species diversity, and will lower the wetland's water quality. Grazing can also expose wetland plant tubers to foraging geese (Weller 1990). In rare situations, grazing could have positive effects, for example, some species such as the upland sandpiper, which may nest in the drier parts of the wetland or in adjacent buffer areas, prefer shorter vegetation for nesting (Weller 1990, 1994). Unless livestock grazing can be kept closely controlled and the effects on vegetation and soils carefully monitored, grazing is not a useful management tool. Well-maintained fences can exclude livestock from a wetland (Stevens and Vanbianchi 1993). Limited grazing may be allowed in upland buffer areas, if the grazing pressure is kept low enough to allow for successful establishment of the desirable vegetation (Welsch 1991). See Appendix C, "Resource Materials and Sources," for supplier information.

6.2.7.2 Trapping

If fencing is impractical because of the size of the wetland and grazing is severe enough to prevent vegetation establishment at the site, trapping or other measures may be necessary to limit wildlife damage. Left unchecked, muskrat populations can increase rapidly and drastically change the character of a marsh. One option for management is a hands-off approach, that is, to allow the cycle of population increase and subsequent crash to occur unimpeded by humans. When muskrat populations prevent realization of project goals, population control measures may be appropriate. The two primary methods of muskrat population regulation are trapping and water-level control (Bishop *et al.* 1979).

Beavers can also become a problem at planned wetland sites because they can alter intended water levels by damming culvert structures, and they can damage plant materials by their feeding. The most feasible approach to beaver management is to maintain small populations and develop ways to circumvent potential damage caused by beavers that remain at the site (Yoakum *et al.* 1980). Unwanted beavers can be trapped using either live or leghold traps. Shooting can also be used to control beavers (Hammerson 1994). See Appendix C, "Resource Materials and Sources," for supplier information.

If wild animals are to be trapped or shot at the wetland site, permits granted from the IDNR Division of Wildlife Resources must be acquired before action is taken. The landowner has three options for controlling nuisance beaver and muskrats. First, landowners may trap animals during the harvest season; they must purchase a license and a Habitat Stamp. Harvest seasons vary annually, but generally in the northern half of the state (north of US 136), the harvest season is from early November through early January; in the southern half of the state, the season is from mid-November to mid-January. The second option applies if the landowner or tenant chooses to control animals outside of the harvest season, or with a method other than trapping, usually shooting. In this case, the landowner or tenant is required to obtain a Nuisance Animal Removal Permit, which can be acquired from an IDNR District Wildlife Biologist or the county Conservation Police Officer. The third option applies to a commercial trapper who is hired by the landowner to control nuisance animals. The trapper must be licensed with a Nuisance Wildlife Control Permit. Contact the IDNR Division of Wildlife Resources (Appendix B, "Natural Resources Agencies") for additional information concerning licenses, habitat stamps, and nuisance animal permits.

6.2.8 Habitat enhancement

The first step in creating habitat for one or more target species is to determine the optimal nesting or foraging habitat for each species. If a group of desired species has conflicting needs, the manager may be able to manage separate parts of the site for individual species on a large site, or may need to set priorities for species and manage for the species considered most important. In many areas, providing nesting and foraging habitat for waterfowl may be a goal of the wetland project. Managers can refer to Smith (1961), Smith (1979), Bohlen (1989), Hoffmeister (1989), Herkert (1992), and Page (1985) for information describing the habitat requirements for Illinois animals. For information on habitat for waterfowl, refer to Flake (1978), Weller (1994), Payne (1992), and the USDA Soil Conservation Service (1992a). More specific information can be obtained from regional resources professionals (Appendix B).

Before installing artificial habitat features, the wetland manager should determine the availability of natural sites relative to the space requirements of the target wildlife. Managers should encourage use of natural den and nest trees and provide artificial structures only as an alternative (Yoakum *et al.* 1980). The presence of islands will increase carrying capacity, but if enough natural sites exist, other artificial structures may not necessarily have the same effect unless the artificial sites are better protected from predators (Payne 1992).

A number of techniques are available for providing wildlife habitat in the form of islands and nesting structures. Wenzel (1992) suggests the following guidelines for island design and construction. Wetlands in which islands are constructed should be at least 2 hectares (5 acres) in size and have an average water depth greater than 0.6 m (2 ft). Placing the islands as far away from the shore as possible (at least 76 m [250 ft] is recommended) will help prevent predation. The settled height of the island should be at least 0.6 m (2 ft) above normal pool level, and can be anywhere from 3 to 15 m (10 to 50 ft) in diameter, with (6 to 9 m (20 to 30 ft) recommended. Side slopes should be 5:1 or flatter (Payne 1992; Wenzel 1992). Islands for nesting should be seeded to tall grasses (Wenzel 1992). Additional guidelines for creating nesting and resting structures are found in Yoakum *et al.* (1980) and Payne (1992).

6.2.9 Managing human use of wetlands

If the planned wetland site is located on public land, visitor management may be a significant issue. Anticipation of visitor pressures is addressed in the design stage. If special elements such as trails, interpretive areas, and educational materials are included in the design, additional effort will be needed to ensure that these are used as intended and maintained. Sensitive planting areas, developing soils, and special wildlife nesting or foraging areas may need protection from damage.

Periodic maintenance of trails, boundary markers, fences, and interpretive signs is necessary to ensure that they continue to perform their intended functions. Maintaining trails, boundary markers, and fences will help ensure that visitors remain in the designated areas of the site and will result in better protection of sensitive areas. Maintaining visitor interpretive signs will help ensure that visitors are adequately informed of the important natural features of the site.

Illegal trash dumping, off-road vehicle and snowmobile use, vandalism, and plant and animal poaching can present additional challenges to achieving the project goals at a site. Adequate fencing, posting of signs or boundary markers, and increased surveillance can help solve these problems. Periodic site surveillance should be conducted and important site conditions should be checked. Surveillance involves walking the site perimeter, and noting broken fences, trash dumping, vehicle trespass, and missing signs. Significant ecological features should also be monitored. Volunteers can be trained to conduct these surveillance activities (The Nature Conservancy 1991).

Planned wetland sites can be used for many different types of public events. Special events at the site might include open houses, science class field trips, tours given by local conservation groups or government agencies, and volunteer workdates.

6.3 Management schedules

6.3.1 Importance of developing management schedules
Management schedules are a necessary component in developing short- and long-term plans for a planned wetland site. These schedules help wetland managers identify their main goals or problem areas at a site and develop a strategy for attaining or handling them. For regulatory projects, particular goals and objectives for planned wetland maintenance for a given time period following the monitoring phase may have been specified in the permit. The Illinois Nature Preserves Commission, the Illinois Department of Natural Resources, and The Nature Conservancy have jointly developed a three-year management schedule planning process to set priorities and to organize land management needs for state nature preserves (The Nature Conservancy 1991). This process is adaptable for areas other than nature preserves, such as planned wetlands. A brief description of the process is given below. Forms that can be used for developing site management goals and a management schedule can be found in Appendix S and Appendix T respectively. Appendix T also presents a management schedule example.

- Develop management goals and objectives for the planned wetland site (see Appendix S). These goals and objectives should be distributed to all parties involved.

- Determine the time period that will be addressed by the management schedule.

- Develop the management schedule (see Appendix T). The form includes five categories:
  — map symbol/management unit
  — management objective
  — management activity
  — schedule (month/year)
  — key personnel

The map symbol is used to label a specific management unit on a map or aerial photograph. A management unit is a part of the site that receives similar management. Natural communities may be grouped by type. Management objectives should be defined clearly for each management unit. Management activities are tasks that are needed to accomplish management objectives. These activities can be periodic or seasonal, and the preferred time for each activity should be defined. Personnel responsible for each activity are listed on the form.

- Circulate the management schedule to all agencies or groups involved, so that individual responsibilities are widely understood and misunderstandings are avoided.

- Management schedules will require periodic updating, because no wetland project will ever proceed entirely as planned. At the end of the time period described in the schedule, all involved parties can reassess the accomplishments or failures at the site. Management methods can be evaluated at this time. Managers can also develop a management schedule for an additional time period, based on this evaluation.

6.3.2 Calendar of optimal times for implementing management methods
Various management methods are best conducted during certain times of the year. The following list is a compilation of the methods mentioned in previous sections of this chapter and is organized by optimal season for the activity.

Spring
- Erect goose and muskrat exclosures around new plantings.
- Conduct early-spring prescribed burns after green-up of exotics and before natives have initiated growth.
- Apply herbicides for control of unwanted herbaceous vegetation, after green-up of exotics and before natives have initiated growth.
- Apply herbicides as a stump treatment on unwanted woody vegetation.

Summer
- Cut or mow unwanted herbaceous vegetation when root reserves are low following flowering, especially cattail and common reed.
- Disk in hot, dry weather to control unwanted woody vegetation.
- Apply herbicide for purple loosestrife control, before seed heads develop.
- Release insects for biological control of purple loosestrife.

Autumn
- Conduct drawdowns of water level in late autumn for carp and muskrat control, continuing into winter.
- Conduct prescribed burns, especially in late autumn for reed canary grass control.

- Cut, mow, or disk for control of unwanted herbaceous or woody vegetation, follow with optional flooding.
- Apply herbicides as a stump treatment on unwanted woody vegetation.

Winter
- Cut cattails at ice level if flooding is expected in the spring.
- Initiate slow drawdown to encourage herbaceous vegetation reestablishment the following year.
- Cut brush and apply basal bark treatment to woody vegetation.

All seasons
- Survey and replace fencing to protect area from livestock or deer.

6.4. Potential participants in management programs

6.4.1 Professionals

Many natural resources professionals in federal, state, and local agencies and in private business are actively involved with planned wetlands throughout Illinois. Most of the results of their work is unpublished and therefore unavailable in print to the public. Probably the best way to gather information from these people is to contact them directly. Appendix B lists federal, state, and local agencies involved in different aspects of wetland restoration and creation or natural area management.

6.4.2 Landowners

In general, landowners will be responsible for planned wetland site management. As part of the long-term management plan, the ownership of the site or the responsibility for its management may be shifted to another entity. Responsibilities should be clearly stated in the management plan.

6.4.3 Volunteers

Many people have an interest in the natural areas and wildlife in their region and are willing to volunteer on a regular or occasional basis to assist with the management of an area. Volunteers offer a wide range of expertise, from those newly acquainted with natural areas to natural resources professionals. Because many of the management methods described previously are very labor-intensive, wetland managers will be able to achieve the restoration site goals more quickly with additional help. Detailed guidelines for dealing with volunteers are described in The Nature Conservancy's *Steward's Handbook* (1991).

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Appendix A: Glossary

adventive - A plant not indigenous to a region, not well established but apparently becoming naturalized.

alfisol - A soil order, usually light brown in color and high in clay content, upon which forest vegetation historically predominated.

alluvium - A recently deposited soil that would occur near a flooding river; and that has not yet developed structural and textural horizonation characteristics typical of an older soil.

anaerobic bacteria - Soil microorganisms suited to live in an environment without oxygen, *e.g.*, in water-saturated soil.

anaerobic - The absence of molecular oxygen, *e.g.*, in stagnant water or saturated soils.

annual - A plant that undergoes its full life cycle, from seed to plant to seed production to death in one year.

aquatic bed - A type of palustrine wetland dominated by floating-leaved vegetation such as water lilies or pondweeds.

aquatic plants - Plants that are rooted underwater and have submerged or floating foliage.

aquic moisture regime - A soil moisture condition characterized by saturation by ground water or by water of the capillary fringe for at least a few days per year; associated with a seasonal chemical-reducing environment that is virtually free of dissolved oxygen, as in soils in aquic suborders and aquic subgroups.

areal cover - A measure of dominance that defines the degree to which above-ground portions of plants cover the ground surface.

basal area - The cross-sectional area of a tree trunk measured in square inches or square centimeters; basal area is calculated from the diameter at breast height (dbh) and is used as a measure of dominance of a given species.

bentonite - A soft, porous clay formed as a weathering product from volcanic ash; used for lining wetland basins as a means of restricting the downward flow of water.

biological control - The use of a living organism as a predator or competitor of an undesirable organism.

bottomland - Low-lying land immediately surrounding a river, often dominated naturally by floodplain forest. Another more restrictive definition includes only the floodplains of major rivers.

browse line - Herbivory evident as absence of vegetation to a uniform height above ground, often caused by white-tailed deer.

buffer - An upland or other environmental area surrounding a wetland that enhances wetland functions or lessens disturbance; also called filter strip or buffer strip.

bulk density - The weight of a known soil volume compared to the weight of an equal volume of water; used for calculating soil porosity.

calcareous - Soil, water, or rock substrate containing calcium as calcium carbonate; a characteristic of young soils (post-Wisconsinan glaciation) like those in northern Illinois.

capillary fringe - Water above the water table that moves upward in the soil profile as a result of surface tension; the degree to which this occurs is inversely related to the pore size of the soil.

channelization - The straightening and widening or deepening of a stream to speed drainage.

channelized flow - Water flow that is confined within a natural or human-induced drainage way; synonymous with stream flow, though often connoting flow through an excavated waterway.

check dams - Small dams perpendicular to the flow of water in a wetland or stream used to reduce streambank erosion and increase water retention time.

chroma - One of three components used to describe soil color; a measurement of the relative purity or saturation of a color and intensity of distinctive hue as related to grayness.

clay loam - A textural classification describing soil composed of 30-40% clay, 15-50% silt, and 20-45% sand.

coefficients of conservatism - In the floristic quality assessment, numbers assigned to all native Illinois flora indicating their rarity and affinity to undisturbed habitats.

compensation ratio - Relationship between the amount of compensation required as compared with the amount of adverse impact to a wetland.

concretion - In soil, a localized concentration of chemical compounds (*e.g.*, calcium carbonate and iron oxide) within a soil, in the form of a grain or nodule of varying size, shape, hardness, and color; concretions of significance in hydric soils are usually iron oxides and manganese oxides occurring at or near the soil surface, which have developed under conditions of fluctuating water tables.

conductivity (specific conductance) - The ability of an aqueous solution to conduct an electrical current, which is related to the concentration of ionized substances in the water. It is measured as the inverse of the resistance of a solution to flow of an electrical current; values are reported as micromhos per centimeter (µhos/cm), or microsiemens per centimeter (µS/cm) in SI units.

contour - An imaginary line of constant elevation on the ground surface; the corresponding line on a topographical map or grading plans is called a "contour line." A contour interval is the elevation difference between contour lines.

denitrification - The process by which microbes convert nitrogen-containing compounds to molecular nitrogen under anaerobic conditions.

desynchronization - Phenomenon that occurs when flood water is stored in a wetland and released after the flood has reached a peak level.

detritivore - Organism that eats dead organic matter.

diameter at breast height (dbh) - The diameter of a tree trunk at 1.4 m (4.5 ft) from the ground.

dike - A berm constructed of soil material that prevents water drainage from a site.

dispersal corridor - A contiguous cover that links habitats for faunal ranging, *e.g.*, a wooded stream.

dissolved oxygen (DO) - The amount of oxygen dissolved in water; DO is high in cool, fast-running water and low in warm, stagnant water.

dominant species - A species that exerts an influence over other species in the community because of its number, density, or growth form.

drainage swale - A low contour of the landscape, naturally occurring or human-made, that collects surface water flow.

drawdown - A seasonally cyclic natural or artificial removal of water from a wetland system.

ecological amplitude - The specificity required by an organism for a particular habitat type.

ecotype - A subspecies or race uniquely adapted to a certain set of biological or environmental conditions.

edaphic - Pertaining to or influenced by physical, chemical, and biological properties of the soil.

emergent vegetation - Plants that are rooted in inundated or wet soils with plant parts extending above the water.

entisol - A soil order of recently deposited soils that are common along rivers and floodplains.

eutrophic - A condition of a water body that has high nutrient content and high productivity.

evapotranspiration - The process through which water returns to the atmosphere by evaporation from the land surface and surface water bodies and by transpiration from plants. It is quantified as the sum of the volumes of water involved in the evaporation and transpiration components.

exotic plant species - Any species that does not occur naturally in a geographical region, but was introduced either deliberately or accidentally by humans.

fen - A wetland type dominated by graminoid plants and fed primarily by calcareous ground water flowing to the surface.

filter strip - An upland area surrounding a wetland that enhances wetland functions or lessens disturbance; also called buffer or buffer strip

floodflow alteration - The capacity of topographically low-lying areas to hold water which would otherwise cause flooding downstream.

floodplain forest - A palustrine wetland, depressional or riparian, dominated by trees.

food chain (food web) - The movement of energy and nutrients from one group of organisms to another in a series from plants to carnivores; food web refers to interconnecting food chains.

function (wetland) - The physical, chemical, and biological processes or attributes of a wetland.

gabion - An erosion control structure composed of crushed rock enclosed by wire mesh.

geotextile - Biodegradable, fabricated material used to stabilize substrates, retain water, and establish vegetation.

glacial till - Deposits of unsorted mixtures of clay, sand, gravel, and boulders left behind as glaciers recede.

gley page - A portion of the Munsell Soil Color Charts, showing colors that indicate extreme soil wetness.

gleying - The process by which wet soils are chemically reduced, resulting in putty grey, blue, or green colors.

grab sample - A single sample collected near the water's upper surface at a particular time and place that represents the water's composition only at that time and place.

graminoid - Grass-like vegetation such as grasses, sedges, bulrushes, spikerushes, and cattails.

growing season - The portion of the year when soil temperatures are above biologic zero (5° C [41° F]). Growing season can be estimated as the period between the average last freeze date in spring and the average first freeze date in fall.

habitat fragmentation - The scattered and widespread destruction of natural habitat, resulting in the absence of large contiguous expanses of natural communities.

habitat mosaic - A diverse, contiguous array of biological community types.

hemi-marsh - A shallow water wetland with a closely interspersed composition of about 50% emergent vegetation and 50% open water.

herb - Graminoids; forbs; ferns; fern allies; herbaceous vines; tree shrub, and woody vine seedlings less than 1 m (3.3 ft) tall.

herbivory - When organisms feed on vegetation.

high-chroma matrix - When the predominant color of a soil horizon has a chroma of three or above; a higher chroma indicates less frequent saturation.

histic epipedon - A 20-41 cm (8-16 inch) soil layer at or near the surface that is saturated for at least 30 consecutive days during the growing season in most years and contains a minimum of 20% organic matter when no clay is present or a minimum of 30% of organic matter when 60% or more of clay is present.

histosol - A soil order composed of organic soils (mucks and peats) that have organic soil materials in more than half of the upper 0.81 m (32 inches) or that are of any thickness if overlying rock.

horizon - A layer, approximately parallel to the surface of the soil, distinguishable from adjacent layers by a distinctive set of properties produced by soil-forming processes.

hue - A characteristic of color related to one of the main spectral colors (red, yellow, green, blue, or purple), or various combinations of these principle colors; one of the three variables used to describe soil color.

hydric soil - Soil that is saturated, flooded, or ponded long enough during the growing season during most years to develop anaerobic conditions that favor the growth and regeneration of hydrophytic vegetation.

hydrogeology - The study of the movement of ground water and its interrelationships with geologic materials and hydrologic and geologic processes.

hydrology - The study of water, addressing its occurrence, distribution, movements, and chemistry.

hydroperiod - The seasonal variability of inflow, outflow, and storage of water on a site.

hydrophytic vegetation - Plant life that occurs in areas where the frequency and duration of inundation or soil saturation produce permanently or periodically saturated soils of sufficient duration to exert a controllng influence on the plant species present.

inclusion - A small (less than 0.8 hectares [2 acres]), unmapped area of soil within a larger mapped soil type; often with a different moisture regime caused by a slight elevation change.

infiltration - Absorption of water into the soil that does not intercept the water table.

in-kind compensation - Compensation of one wetland community type with the same type, *e.g.*, emergent marsh compensated by emergent marsh.

intermittent stream - A stream where water flows for only part of the year although water may remain in isolated pools within the stream bed.

interspersion - A mixture of cover types at a site.

jurisdictional wetland - A wetland, natural or planned, that meets the state or federally recognized criteria for hydrophytic vegetation, hydric soils, and wetland hydrology.

lacustrine - Pertaining to lakes; a deepwater habitat located in a topographic depression or a dammed river channel with less than 30% areal cover by vegetation, greater than 2 m (6.6 ft) deep and generally larger than 8.1 hectares (20 acres).

loess - Windblown deposits of fine soil.

low-chroma matrix - When the predominant color of a soil horizon has a chroma of two or below; a lower chroma indicates more frequent saturation.

map (mapping) unit - Some common characteristic of soil, vegetation, and/or hydrology that can be shown at a desired map scale for the defined purpose and objectives of a survey.

matrix - The predominant color or texture of greater than 50% of the soil volume within a soil horizon.

mineral soil - Any soil consisting primarily of mineral material (sand, silt, and clay), rather than organic matter.

mitigation - Term often used to describe the compensation for wetland impacts or losses.

mollic color - Soil color dominated by the presence of organic carbon (*e.g.*, dark black) which masks typical hydric soil colors. Colors of any hue with a value less than 4 and chroma less than 2 are considered mollic.

mollic epipedon - A thick dark brown or black surface horizon in soils.

mollisol - A soil order comprising prairie soils with characteristic deep, black topsoil (mollic epipedon).

mottle - A spot of uniform color in a soil horizon making up less than 50% of the soil volume as differentiated from the matrix or a mottle of a different color.

muck - A well-decomposed organic soil where most plant fibers are not recognizable.

native species - A species that occurs in a particular location without deliberate or accidental intervention by humans.

neutral chroma - Color notation for soils used to describe pure white, pure gray, and pure black; indicates a chroma of zero and no hue.

nitrogen fixation - The process by which atmospheric nitrogen is chemically reduced by soil bacteria or blue-green algae to its ammonium form.

nodule - A firm spherical black or red mass in the soil indicating a fluctuating water table, used in this context synonymously with concretion.

non-persistent vegetation - Herbaceous vegetation whose leaves and stems break down at the end of the growing season so that most above-ground portions of the plants are easily transported by wind, currents, waves, or ice.

nutrient sink - An area where chemical compounds (*e.g.*, nitrogen and phosphorus) accumulate.

nutrient transformation - The process by which nitrogen and phosphorus compounds are converted to other forms by interaction with soils, plants, and microorganisms.

off-site compensation - Wetland compensation area located within the same hydrologic unit boundary as but more than one mile from the adversely impacted wetland for which compensation is required.

on-site compensation - Wetland compensation area located within the same hyudrologic unit boundary and within one mile of the adversely impacted wetland for which compensation is required.

organic matter - A component of soil consisting of decaying carbon compounds from plants and animals.

out-of-kind compensation - Compensation for one wetland community type with another type, *e.g.*, emergent marsh compensated by floodplain forest.

overland flow - Water running off the land surface when the rate of precipitation exceeds the infiltration rate into the soil and depressional storage is exceeded; also called runoff, sheet flow, or slope wash.

oxidation-reduction (redox) potential (ORP) - A measure of the voltage difference between oxidized and reduced soil metals, referenced against a standard hydrogen electrode as influenced by wetness and acidity (pH). Wet soils have a lower redox potential than similar drier soils.

palustrine - Shallow freshwater habitat dominated by trees, shrubs, or persisent emergent vegetation, or open water less than 2 m (6.6 ft) deep and less than 8.1 hectares (20 acres) in size.

panne - A moist interdunal depression in calcareous sands on the lee sides of dunes near Lake Michigan, with fen-like vegetation.

peat - A partially decomposed organic soil where most plant fibers are recognizable.

ped - A small unit of soil that has been broken along its natural planes.

pedology - The study of soils; soil science.

penetrometer - An instrument used to determine the degree of soil compaction by measuring the pounds of pressure per square inch required to push the measuring rod of the instrument into the ground.

perched ground water - Water in an isolated, saturated zone located in the zone of aeration, being the result of a layer of material with low hydraulic conductivity called the perching bed. Perched ground water will have a perched water table, because it is unconfined.

percolation - The downward movement of water through the soil.

perennial - A plant that maintains some living tissue throughout the year and sprouts leafy vegetation for more than two growing seasons.

performance standards (criteria) - Threshhold values or criteria for quantifiable, biological or physical parameters related to a given wetland component, and used to determine project success. Also referred to in this guide as success criteria (standards).

permeability - A characteristic of a soil that enables water to move downward through the profile, measured in number of inches per hour.

persistent vegetation - Woody or herbaceous vegetation that normally remains standing at least until the beginning of the next growing season.

pH - An expression of the intensity of the basic or acid condition of the water or soil; acidic solutions and soils have a pH below 7 and alkaline solutions and soils have a pH above 7.

planned wetland - A term used in this guide that comprises both restored and created wetlands.

plant productivity - The weight of new plant material (biomass) formed over a period of time, adjusted for losses attributable to respiration, death, grazing, etc.

pond - A palustrine wetland, either human-made or natural, dominated by open water typically less than 2 meters (6.6 feet) in depth, and less than 8.1 hectares (20 acres) in size.

prairie pothole - A depressional, palustrine, emergent wetland found in the Upper Midwest and formed by glacial processes.

presettlement vegetation - The flora present in a particular location prior to the arrival of European settlers.

primary productivity - The amount of new organic material produced by photosynthesis, or the stored energy this material represents.

relic hydric soil - A currently drained soil that has retained morphological features indicating a long history of wetness.

retention time - The amount of time it takes for for a volume of water flowing into a wetland to flow out of the wetland. It is calculated by dividing the volume of water in the system by the rate of outflow.

riparian - Pertaining to the area surrounding a stream or river that is at least periodically influenced by flooding.

riverine - Wetlands and deepwater habitats contained within a channel and having periodically or continuously moving water.

salinity - The combined ionic concentrations of four major cations (calcium, magnesium, sodium, and potassium), and four major anions (bicarbonate, carbonate, sulfate, and chloride); expressed as mg/L or meq/L.

sand lens - A subsurface deposit of sand that may impair the ability of a potential site to hold water.

sapling - Woody vegetation between 2.5 and 13 cm (1 and 5 inches) in dbh and at least 6 m (20 ft) in height, exclusive of woody vines.

saturated - As it pertains to soil conditions, a condition in which all or most pores between soil particles are temporarily or permanently filled with water.

scrub-shrub wetland - A palustrine wetland characterized by dominant woody vegetation less than 6 m (20 ft) tall and saturated soils or standing water.

sedge meadow - A saturated or shallow water emergent wetland dominated by sedges typically of the genus *Carex*.

sedimentation - The settling of soil particles and pollutants on the soil surface.

seed bank - A reservoir of ungerminated seeds within the soil.

seep - A wetland formed where cool, moderately calcareous ground water flows to the surface. Seeps can be dominated by herbaceous or woody plants.

sheet flow - See overland flow.

shrub - Woody vegetation between 1 m (3 ft) and 6 m (20 ft) tall and with dbh less than 2.5 cm (1 inch), including multi-stemmed, bushy shrubs and small trees and saplings.

silt loam - A classification of soil texture composed of approximately 20-50% sand, 0-25% clay, and 50-85% silt.

slope wash - See overland flow.

soil horizon - A layer of soil or soil material approximately parallel to the land surface, of variable thickness, differing from adjacent layers produced by similar soil forming processes in physical, chemical, and biological properties or characteristics (*e.g.,* color, structure, and texture).

soil pore - A void within soil occupied by either water or air, resulting from the arrangement of individual soil particles or peds.

soil profile - A vertical section of the soil through all of its horizons and extending into the parent material.

soil series - Basic unit of soils classification consisting of soils having horizons similar in differentiating characteristics and arrangements in the soil profile, except for texture of the surface layer, slope, gravel, stones, and amount of erosion.

soil taxonomy - The science of classifying soils with respect to external factors of soil formation such as climate, organisms, relief, parent materials, and time.

soil texture - The physical nature of soil resulting from the relative proportions of sand, clay, and silt.

soil type - Lowest unit in the soil classification system consisting of soils which are alike in all characteristics, including the surface horizon.

sounding rod - A measuring rod for determining water depth.

stratum - A layer of vegetation within a biological community, *e.g.*, herbaceous, shrub, sapling, tree, and woody vine.

subsurface drain - System of water-permeable clay or plastic pipe installed beneath the ground surface to facilitate drainage.

substrate - The base or substance utilized for attachment upon which an organism lives, *e.g.*, the soil is the substrate for vegetation.

subsurface flow - Vertical and lateral movements of ground water into and out of a site.

success criteria - See performance standards.

succession(al) - The replacement of one set of biological communities by another over time.

sulfidic odor - An indicator of nearly continuous soil saturation caused by hydrogen sulfide released by sulphur-reducing bacteria.

swamp - A permanently or semi-permanently flooded wetland with an areal canopy coverage of greater than 30% in the tree stratum. In Illinois, most common in the southernmost part.

tile - A subsurface porous pipe used to drain excess water from a tract of land.

tree - Woody vegetation at least 6 m (20 ft) tall, with dbh of 13 cm (5 inches) or greater.

topography - The configuration of a surface, including its relief and the position of its natural and human-made features.

turbidity - The extent to which light passes through water as influenced by suspended sediments and bacterial or algal growth.

upland - Any area that does not qualify as a wetland as a result of a lack of wetland hydrology, hydric soils, and/or hydrophytic vegetation.

value - The relative lightness or intensity of color; one of three components of soil color.

vertical stratification - The presence of more than one stratum within a biological community, *e.g.*, the herbaceous and tree strata of a floodplain forest.

woody vine - A woody plant with a trailing or climbing stem, not self-supporting. Herbaceous vines are typically included with the herbaceous stratum.

volatilization - The process by which compounds are changed to the gaseous form and subsequently dispersed to the atmosphere

water budget - An accounting of the inflow to, outflow from, and storage within a hydrologic unit.

water quality - A wetland function referring to a wetland's capacity to retain and process dissolved or particulate materials to the benefit of downstream water quality.

water regime - The characteristics of the presence of water at a site, including the depth, duration, and season in which an area is saturated or inundated with water.

watershed - The region or area drained by a particular body of water; can range in size from the area draining a small stream to the Mississippi River.

weir - A type of water control structure.

wetland - Area that under normal circumstances has hydrophytic vegetation, hydric soils, and wetland hydrology.

wetland compensation - The replacement of wetland functions and area to offset an adverse wetland impact.

wetland creation - Constructing a wetland where one never existed historically.

wetland hydrology - Characterized by periodic inundation or having soils saturated to the surface at some time during the growing season.

wetland indicator status - The category assigned to a particular plant species based on the likelihood that the species generally occurs in wetlands (OBL, FACW, FAC, FACU, or UPL).

wetland restoration - The re-establishment of a wetland in the landscape where a wetland existed historically.

Appendix B: Natural Resources Agencies

Illinois Department of Natural Resources
Office of Resource Conservation
Division of Natural Heritage Regional Offices

Main Office
Division of Natural Heritage
524 S. Second St.
Springfield, IL 62701
(217) 785-8774

Districts 1-6
2612 Locust Street
Sterling, IL 61081
(815) 625-2968

Districts 7-14
2005 Round Barn Rd.
Champaign, IL 61821
(217) 333-5773

Districts 15-20
4521 Alton Commerce Pkwy
Alton, IL 62002
(217) 462-1181

Districts 21-26
11731 State Highway 37
Benton, IL 62818
(618) 435-8138

District Heritage Biologists

District 1
Dearborn Hall
205 E. Seminary St.
Mt. Carroll, IL 61053
(815) 244-3655

District 2
Castle Rock State Park
1365 W. Castle Road
Oregon, IL 61061
(815) 732-6185

District 3
IVCC E. Campus Bldg. 11
815 N. Orlando Smith Rd.
Oglesby, IL 61348-9691
(815) 224-4048

Districts 4&6
116 North East Street
P.O. Box 23
Cambridge, IL 61238
(309) 937-2122

District 5
215 N. 5th, Ste. D
Pekin, IL 61554
(309) 347-5119

Districts 7&8
110 James Road
Spring Grove, IL 60081
(815) 675-2385

Districts 9&20
vacant

District 10
Silver Springs State Park
13608 Fox Road
Yorkville, IL 60560
(708) 553-1372

Districts 11&12
Midewin National Tallgrass Prairie
30071 South State Route 53
P.O. Box 88
Wilmington, IL 60481
(815) 423-6370

District 13
2005 Round Barn Rd.
Champaign, IL 61821
(217) 333-5773

District 14
R.R. 2, Box 108
Charleston, IL 61920
(217) 345-2420

District 15
Route 106 West, P.O. Box 477
Pittsfield, IL 62363
(217) 285-2221

District Heritage Biologists, cont.

District 16
700 S. 10th St.
Havana, IL 62644
(309) 543-3401

District 17
Sangchris Lake State Park
9898 Cascade Rd.
Rochester, IL 62563
(217) 498-8534

Districts 18&19
4521 Alton Commerce Parkway
Alton, IL 62002
(618) 462-1181

Districts 21&22 and Prairie-chicken Sanctuary
4295 N. 1000th
Newton, IL 62448
(618) 783-2685

District 23
R.R. 3, Box 328-6
Marion, IL 62959
(618) 993-7094

District 24
Dixon Springs State Park
R.R. 2
Golconda, IL 62938
(618) 949-3305

District 25
Ferne Clyffe State Park
P.O. Box 67
Goreville, IL 62939
(618) 995-2568

District 26
R.R. 1, Box 53-E
Ullin, IL 62992
(618) 634-2524

Illinois Nature Preserves Commission - Natural Areas Preservation Specialists

Main Office
Illinois Nature Preserves Commission
600 North Grand Avenue West
Springfield, IL 62706
(217) 785-8686

Northeastern Illinois Threats Coordinator
407 King Avenue
East Dundee, IL 60118

Area 1
320 South Third Street
Rockford, IL 61104
(815) 987-7398

Area 2
Moraine Hills State Park
914 South River Road
McHenry, IL 60050
(815) 385-9074

Area 3
Midewin National Tallgrass Prairie
30071 South State Route 53, P.O. Box 88
Wilmington, IL 60481
(815) 423-6370

Area 4
Argyle Lake State Park
640 Argyle Park Road
Colchester, IL 62326
(309) 776-3422

Area 5
Mason State Nursery
R.R. 1, Box 235
Topeka, IL 61567
(309) 535-2185

Area 6
P.O. Box 497
Sidney, IL 61877
(217) 688-2622

Area 7
1115 South Fifth
P.O. Box 520
Coulterville, IL 62237

Area 8
R.R. 3, Box 979, P.O. Box 206
Fairfield, IL 62837
(618) 842-2179

Area 9
4648 Highway 127
Carbondale, IL 62901
(618) 684-2660

Endangered Species Protection Board
Lincoln Tower Plaza
524 S. Second St.
Springfield, IL 62702-1787
(217) 785-8774

Division of Wildlife Resources
524 S. Second St.
Springfield, IL 62702-1787
(217) 782-6384

Wetlands Programs
600 North Grand Ave. W.
Springfield, IL 62706
(217) 785-8287; 785-5500

Office of Water Resources
Main Office
524 S. Second St.
Springfield, IL 62701
(217) 782-3863

Northeastern Area
201 West Center Court
3rd Floor East
Schaumburg, IL 60196-1096
(708) 705-4341

Lake Michigan Management Section
Room 1606
310 South Michigan
Chicago, IL 60604
(312) 793-3123

Illinois State Geological Survey
121 Natural Resources Building
615 E. Peabody Dr.
Champaign, IL 61820
(217) 333-4747

Illinois State Water Survey
Water Survey Research Center
2204 Griffith Dr.
Champaign, IL 61820
(217) 333-2210

Illinois Natural History Survey
607 E. Peabody Drive
Champaign, IL 61820
(217) 333-6880

Illinois Waste Management and Research Center
1E Hazelwood Drive
Champaign, IL 61820
(217) 333-8944

Illinois Department of Agriculture
Bureau of Environmental Programs
800 Sangamon Ave., State Fairgrounds
Springfield, IL 62794
(800) 641-3934; (217) 785-2427

Bureau of Farmland Protection
P.O. Box 19281, State Fairgrounds
Springfield, IL 62794-9281
(217)782-6297

Illinois Department of Transportation
Bureau of Design and Environment
Room 330
2300 South Dirksen Parkway
Springfield, IL 62764
(217) 782-9129

Illinois Environmental Protection Agency
Division of Water Pollution Control
Permit Section
2200 Churchill Rd.
Springfield, IL 62794-9276
(217) 782-0610

County Agencies
Champaign County Forest Preserve District
109 S. Lake of the Woods Rd.
Mahomet, IL 61853

Forest Preserve District of DuPage County
185 Spring Avenue P.O. Box 2339
Glen Ellyn, IL 60138

Kane County Forest Preserve District
719 Batavia Ave.
Geneva, IL 60134

Lake County Forest Preserve District
2000 N. Milwaukee Ave.
Libertyville, IL 60048

McHenry County Conservation District
6512 Hart Road
Ringwood, IL 60072

Forest Preserve District of Will County
Cherry Hill Rd. and Rt. 52, R.R. 4
Joliet, IL 60433

U.S. Department of Agriculture - Natural Resources Conservation Service

Illinois State Office
1902 Fox Dr.
Champaign, IL 61820
(217) 398-5287

County offices - In each Illinois county, call the Natural Resources Conservation Service (NRCS). Listed in phone book under United States Government.

U.S. Fish and Wildlife Service

Chicago Illinois Field Office
1000 Hart Road, Suite 180
Barrington, IL 60010
(847) 381-2253

Rock Island Field Office
4469 48th Avenue Court
Rock Island, IL 61201
(309) 793-5800

Marion Sub-Office
R.R. 3, Box 328
Marion, IL 62959
(618) 997-5491

U.S. Army Corps of Engineers

Rock Island District
Clock Tower Building
P.O. Box 2004
Rock Island, IL 61201-2004
(309) 794-4200/5900

Chicago District
111 N. Canal St., Suite 600
Chicago, IL 60606-7206
(312) 353-6428

St. Louis District
210 Tucker Blvd. North
St. Louis, MO 63101-1986
(314) 331-8010

Louisville District
600 Federal Place
P. O. Box 59
Louisville, KY 40201-0059
(502) 582-5601

Memphis District
B-202, Clifford Davis Federal Building
Memphis, TN 38103-1894
(901) 544-3221

U.S. Army Engineer Waterways Experiment Station
Wetland Research Program
3909 Halls Ferry Road
Vicksburg, MS 3910-6199
(601) 634-4217

U.S. Environmental Protection Agency

U.S. EPA Region 5
77 West Jackson Blvd.
Chicago, IL 60604
Water Supply Branch (312) 353-2151
Wetlands and Watersheds Section 886-0243

EPA Safe Drinking Water Hotline:
1-800-426-4791

EPA Wetlands Information Hotline:
1-800-832-7828

Appendix C: Resource Materials and Sources

The following list contains sources of information or supplies that are useful in the wetland restoration and creation process. Listing a supplier does not constitute an endorsement of its products, nor does the absence of listing a possible supplier discredit any of its products. These sources are those about whom we have some knowledge.

Maps and aerial photographs

National Wetlands Inventory - hard copy maps for Illinois	Map Sales Coordinator Center for Governmental Studies Northern Illinois University DeKalb, Illinois 60115 (815) 753-0914
National Wetlands Inventory - digital data for the U.S.	Administrator for Wetlands, Watershed and EMP Programs Office of Resource Conservation Illinois Department of Natural Resources 600 North Grand Ave. W. Springfield, Illinois 62706 (217) 785-8287
To access NWI digital data via the Internet (mapping software and Internet access required)	Via USFWS server: ftp 192.189.43.33 name: anon password: path name (address) follow instructions on screen; refer to "read me" files
United States Geological Survey 7.5-minute quadrangle topographic maps for the entire state	Illinois State Geological Survey 615 E. Peabody Drive Champaign, Illinois 61820 (217) 333-4747
United States Geological Survey 7.5-minute quandrangle topographic maps for the Chicago metropolitan area	Rand McNally Map and Travel Store 444 N. Michigan Ave. Chicago, Illinois 60611 (312) 321-1751
Aerial photographs	In each Illinois county, call the Farm Services Agency [formerly Agricultural Stabilization and Conservation Service (ASCS)] to order aerials. Listed in phone book under United States Government.
General Land Office plats of Illinois (1807-1891) and Public Land Survey Field Notes	Illinois State Library, Springfield - Photocopies of microfilm available. To identify area requested, obtain index map by calling (217) 782-5823. Request photocopies of microfilm via inter-library loan at local library. Illinois State Geological Survey Library, Champaign - General Land Office plats available on microfilm. Library visit required. phone: (217) 333-5110 Illinois Historical Survey - Field notes available on microfilm. Library visit required. Room 346, Main Library, Champaign. phone: (217) 333-1777

General Land Office plats of Illinois (1807-1891) and Public Land Survey Field Notes, cont.	Newberry Library, Chicago - photocopies of microfiche and microfilm of plat maps and field notes available for fee. Submit requests with location information to: Special Collections Newberry Library 61 W. Walton Chicago, Illinois 60610 (312) 943-9090 Plats: Microfiche 2710 Notes: Microfilm 1176
Soil mapping information	
County soil surveys, county hydric soil lists, and NRCS wetland maps	In each Illinois county, call the Natural Resources Conservation Service (NRCS). Listed in phone book under United States Government.
Field survey equipment	
Vegetation	
Flagging, measuring tapes, clipboards, increment borers, Redy mapper, plant presses, etc.	Forestry Suppliers, Inc P. O. Box 8397 Jackson, Mississippi 39284-8397 phone: (800) 543-5368
	Ben Meadows Company 3589 Broad Street Atlanta, Georgia 30341 phone: (800) 241-6401
	Carolina Biological Supply Company 2700 York Road Burlington, North Carolina 27215 phone: (800) 334-5551
Animals	
Sherman traps, live traps, insect nets, aquatic nets, dip nets, snake sticks, etc.	Carolina Biological Supply Company (address above)
	BioQuip Products 17803 LaSalle Avenue Gardena, California 90248-3602 phone: (310) 324-0620
	H. B. Sherman Traps P. O. Box 20267 Tallahassee, Florida 32316 phone: (904) 562-5566
Water	
Water quality testing kits, electronic field instruments	Forestry Suppliers, Inc. (address above)
	Cole Palmer Instrument Company 7425 North Oak Park Avenue Niles, Illinois 60714 phone: (800) 323-4340
Soil	
Munsell color chart, soil and tile probes, penetrometers, etc.	Forestry Suppliers, Inc. (address above)
Color chart for estimating organic matter in mineral soils in Illinois	Information Services College of Agricultural, Consumer and Environmental Sciences University of Illinois 1401 South Maryland Drive Urbana, Illinois 61801 phone: (217) 244-2834

Construction supplies

DOS-IR®valves and gates

Fiberglass Utility Supplies, Inc.
1465 250th St.
Libertyville, Iowa 52567-8523
phone: (515) 693-3311
FAX: (515) 693-4131

Clemson Beaver Pond Leveler

Department of Aquaculture, Fisheries and Wildlife
G08 Lehotsky Hall
Clemson University
Clemson, South Carolina 29634
phone: (803) 656-3117

Survey equipment, silt fencing, water level control structures, etc.

Agri Drain Corporation
P.O. Box 458, 1462 340th St.
Adair, Iowa 50002
phone: (800) 232-4742
FAX: (800) 282-3353

Vegetation management and establishment supplies

Wildflower and large seed planters, grass and grain seed drills

Truax Company, Inc.
3609 Vera Cruz Avenue North
Minneapolis, Minnesota 55422
(612) 537-6639

Natural fiber products - coir (coconut) and jute, natural tackifier, soil stabilizers

Agri Drain Corporation
(address above)

Eastern Products, Inc.
1162 Sycamore Lane
Nahwah, New Jersey 07430
(800) 934-0809

Deer repellants, tree protection tubes, sprayers

Forestry Suppliers, Inc.
(address above)

Weather information

State Climatologist
Illinois State Water Survey
2204 Griffith Drive
Champaign, Illinois 61820-7495
(217) 333-0729

National Climatic Data Center
151 Patton Avenue, Room 120
Asheville, North Carolina 28801-5001
phone: (704) 271-4800
FAX: (704) 271-4876

Water resources data

Illinois State Water Survey (address above)
(217) 333-2210

U.S. Geological Survey
Water Resources Division
102 E. Main St., 4th Floor
Urbana, Illinois 61801

Appendix D: Illinois Wetland Communities

The Illinois Natural Areas Inventory (INAI) (White 1978) defines wetlands as communities that are flooded or have hydric soils, and that have vegetative cover. The following wetland community descriptions were modified from the INAI and include information about the distribution, vegetation structure, species composition, soils, and moisture conditions within the community. Illinois natural wetland hydrology is poorly understood, and the descriptions do not include a complete discussion of this component. Wetland hydrology can be inferred from soils information.

Floodplain forest

Forests are characterized by an average canopy cover of at least 80%. Flooding in wet floodplain forests is so frequent or prolonged that the tree diversity is reduced. The understory and often the overstory are open. Nettles and vines are often prominent.

Distribution

Floodplain forests occur on the floodplains of streams and in isolated depressions throughout the state. The most extensive tracts are on lake plains and behind natural levees of major rivers.

Common plants

Boxelder (*Acer negundo*), red maple (*Acer rubrum*), silver maple (*Acer saccharinum*), river birch (*Betula nigra*), sycamore (*Platanus occidentalis*), cottonwood (*Populus deltoides*), and black willow (*Salix nigra*)

Characteristic animals

Many amphibians, great blue heron, Acadian flycatcher

Typical soils

Soils consist of fine textured alluvium. Sawmill silty clay loam is a typical wet floodplain forest soil in Illinois prairie regions. This soil is poorly drained. Permeability is 1.5 to 5.0 cm/hr (0.6 to 2.0 inches/hr) throughout the soil profile (0 to 152 cm [0 to 60 inches]). Sawmill soil is flooded occasionally for brief durations March through May. The high water table is apparent and is 0 to 0.6 m (0 to 2.0 ft) below the ground surface March through June.

Wet prairie and wet sand prairie

Prairies are communities generally dominated by grasses (or, locally, low shrubs) on mineral soil. Plant species diversity is lower than other prairie communities. Trees may be present, but less than 10% of the area has a tree canopy.

Distribution

Wet prairie was generally distributed throughout the prairie regions of Illinois.

Common plants

Wet prairie: Indian plantain (*Cacalia tuberosa*), blue-joint grass (*Calamagrostis canadensis*), sedges (*Carex* spp.), boneset (*Eupatorium perfoliatum*), wild blue iris (*Iris virginica* var. *shrevei*), winged loosestrife (*Lythrum alatum*), water parsnip (*Sium suave*), prairie cord grass (*Spartina pectinata*)
Wet sand prairie: blue-joint grass (*Calamagrostis canadensis*), sedges (*Carex* spp.), prairie cord grass (*Spartina pectinata*), marsh fern (*Thelypteris palustris*)

Characteristic animals

Common yellowthroat, sedge wren, and swamp sparrow

Typical soils

Soils are deep and fine-textured, usually silt loam or clay loam. Parent material is loess, glacial till, or alluvium. Surface water is present during the winter and spring, and the soil is nearly always saturated. Drummer silty clay loam is a typical wet prairie soil. This soil is poorly drained. Permeability is 1.5 to 0.5 cm/hr (0.6 to 0.2 inches/hr) throughout the soil profile (0 to 152 cm [0 to 60 inches]). The high water table is apparent and is +0.15 to 0.6 m (+0.5 to 2.0 ft) from the ground surface March through June. Under wet sand prairie, soils are coarse-textured, consisting of sand, loamy sand, and sandy loam. Sand prairies are found on sandy outwash plains, lake plains, and valley trains. Surface water is present for up to four months annually.

Marsh

Tall graminoid (grass-like) plants dominate marsh communities, which have water near or above the soil surface for most of the year. Marshes are located in glacial potholes, in river valleys, and on lake plains, and support a wide variety of plant communities. In general, plant species diversity decreases with increasing water depth. Fluctuations in water levels, fire frequency, and muskrat population cycles are also important in determining species composition.

Distribution

Once very widespread, natural marshes are now common only in the Northeastern Morainal Natural Division. Disturbed remnants of larger marshes exist in the Grand Prairie, and marshes fringe the navigational pools of the Illinois River.

Common plants

Water plantain (*Alisma* spp.), false aster (*Boltonia asteroides*), lake sedge (*Carex lacustris*), swamp loosestrife (*Decodon verticillatus*), common reed (*Phragmites australis*), water

smartweed (*Polygonum amphibium*; *P. coccinium*), ditch stonecrop (*Penthorum sedoides*), arrow leaf (*Sagittaria latifolia*), marsh skullcap (*Scutellaria epilobiifolia*) river bulrush (*Scirpus fluviatilis*), soft-stem bulrush (*Scirpus validus*), narrow-leaved cattail (*Typha angustifolia*), cattail (*T. latifolia*)

Characteristic animals
Muskrat, yellow-headed blackbird, rails, bitterns, swamp sparrow, pied-billed grebe, and many waterfowl

Typical soils
Soils consist of mineral or organic material. Peotone is a common soil type of marshes in Illinois prairie regions. This soil is located in isolated depressions on uplands. Areas of this soil are commonly circular or elliptical in shape and are generally 0.8 to 12 ha (2 to 30 acres) in size. Peotone is poorly drained. The wet phase is very poorly drained. Permeability is 0.5 to 1.5 cm/hr (0.2 to 0.6 inches/hr) at depths 0 to 101 cm (0 to 40 inches) and 0.15 to 0.5 cm/hr (0.06 to 0.2 inches/hr) at depths below 101 cm. Peotone is flooded occasionally for long durations February through July; wet phases are flooded frequently for long durations February through July. The high water table is perched and is 0 to 0.3 m (0 to 1.0 ft) from the ground surface February through July.

Swamp
A swamp is a wetland dominated by woody plants. Two communities, true swamp and shrub swamp, are recognized on the basis of vegetation structure. A true swamp is a forested, permanent or semi-permanent body of water.

Distribution
Swamps are limited to extreme southern Illinois, because only southern tree species (except for tamarack [*Larix laricina*]) can live in permanent bodies of water.

Common plants
Button bush (*Cephalanthus occidentalis*), pumpkin ash (*Fraxinus tomentosa*), Virginia willow (*Itea virginica*), tupelo gum (*Nyssa aquatica*), swamp rose (*Rosa palustris*), black willow (*Salix nigra*), bald cypress (*Taxodium distichum*)

Characteristic animals
Mole salamander, green treefrog, bird-voiced treefrog, prothonotary warbler, wood duck

Typical soils
Soils consist of fine-textured mineral material. Karnak clay and Piopolis silty clay loam are typical soil types of swamps in southern Illinois. These soils are found in the Cache River-Bay Creek bottomlands and in old swales or bayous in the Ohio and Mississippi River bottomlands. Both soil types are poorly drained or very poorly drained. Permeability for both Karnak and Piopolis soils ranges from 0.13 to 0.5 cm/hr (0.05 to 0.2 inches/hr) in the upper horizon to 0 to 0.13 cm/hr (0 to 0.05 inches/hr) in the lower horizon. Depth to seasonal high water table is 0 to 0.9 m (0 to 3 ft) for both soil types. Both soils are subject to flooding and overflow.

Shrub swamp
A shrub swamp has at least 50% shrub cover; a body of shallow water with less coverage is termed a pond. A shrub swamp has less than 20% coverage by trees, or else it is classified as a swamp. Shrub swamps are often associated with ponds in wet floodplain forests. Occasionally, shrub swamps occur in glacial potholes, where they grade into the tall shrub bog community.

Distribution
Shrub swamps are generally distributed throughout the state.

Common plants
Speckled alder (*Alnus rugosa*), button bush (*Cephalanthus occidentalis*), red-osier dogwood (*Cornus stolonifera*), pussy willow (*Salix discolor*), sandbar willow (*Salix exigua*)

Characteristic animals
Willow flycatcher, yellow warbler

Typical soils
Soils of shrub swamps are similar to those of swamps in southern Illinois and wet floodplain forest and marsh communities in central and northern parts of the state.

Sedge meadow
A sedge meadow is a wetland dominated by sedges (*Carex* spp.) on peat, muck, or wet sand. The sedge meadow is remarkably homogeneous in composition and structure. Some degree of floristic overlap exists between the sedge meadow and wet prairie.

Common plants
Swamp aster (*Aster puniceus* var. *lucidulus*), blue-joint grass (*Calamagrostis canadensis*), lake sedge (*Carex lacustris*), sedge (*Carex lasiocarpa*), tussock sedge (*Carex stricta*), turtle head (*Chelone glabra*), bog willow herb (*Epilobium leptophyllum*), spotted Joe-Pye-weed (*Eupatorium maculatum*)

Characteristic animals
Sora, Virginia rail

Typical soils
The soil and soil moisture levels of sedge meadows are similar to those of wet prairies.

Pond

A pond is a small, still body of water, usually shallow enough (<2 m [6.6 ft]) to allow rooted aquatic plants to grow across most of it. All ponds in Illinois, even those associated with bogs, appear to be nutrient rich (eutrophic). A pond is permanently or semi-permanently inundated, not seasonal or ephemeral.

Distribution

Many bodies of water in Illinois, including many backwater sloughs connected to major rivers, are classified as pond communities rather than lakes.

Common plants

Yellow pond lily (*Nuphar advena*), white water lily (*Nymphaea tuberosa*), smartweed (*Polygonum* spp.), pondweed (*Potamogeton* spp.), duckweed (*Spirodela* spp.; *Lemna* spp.)

Characteristic animals

Bullfrog, mudminnow, golden shiner, black bullhead, pugnose minnow, pigmy sunfish, slough darter

Literature Cited

White, J. 1978. Survey methods and results. Illinois Natural Areas Inventory, Urbana. Technical Report Volume 1. November.

Appendix E: Vegetation Cover Types

The vegetation cover types described below are derived from the Illinois Natural Areas Inventory (INAI) (White 1978) and have been modified for conducting field surveys. Following each description in parentheses is the corresponding cover type terminology developed for use in habitat suitability models and Habitat Evaluation Procedures (HEP) (USFWS 1980). HEP terminology for wetlands and deepwater habitats is compatible with National Wetlands Inventory coding and the USFWS classification system (Cowardin *et al.* 1979).

1. **Forbland** - Abandoned pastures and successional fields dominated by disturbance-adapted and disturbance-tolerant forbs. Common herbaceous plants are wild carrot (*Daucus carota)*, smooth brome (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis*), hairy aster (*Aster pilosus*), thistle (*Cirsium* spp.), sweet clover (*Melilotus* spp.), white snakeroot (*Eupatorium serotinum*), tall boneset (*Eupatorium altissimum*), black-eyed Susan (*Rudbeckia hirta*), tall goldenrod (*Solidago canadensis*), purple-top (*Tridens flavus*), ragweed (*Ambrosia* spp.), and clover (*Trifolium* spp.). Shrub cover should not exceed 25% of the overall areal cover. Typical shrub species include multiflora rose (*Rosa multiflora*), coralberry (*Symphoricarpos orbiculatus*), wild blackberry (*Rubus* spp.), and hazelnut (*Corylus americana*). This cover type also includes sites dominated by cool-season grasses and disturbance-tolerant prairie forbs, *e.g.,* wild bergamot (*Monarda fistulosa*), rigid goldenrod (*Solidago rigida*), yellow coneflower (*Ratibida pinnata*), and prairie dock (*Silphium* spp.). (forbland, shrub savanna)

2. **Pasture** (≤ 5% areal cover with woody vegetation) - Dominated by planted forage grasses and legumes, especially smooth brome (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis*), meadow fescue (*Festuca pratensis*), and clover (*Trifolium* spp.). Common trees and shrubs are honey-locust (*Gleditsia tricanthos*), osage-orange (*Maclura pomifera*), hackberry (*Celtis occidentalis*), and multiflora rose (*Rosa multiflora*). Pastures may be grazed forests or savannas with an understory of planted grasses; oaks (*Quercus* spp.), hickories (*Carya* spp.), black locust (*Robinia pseudoacacia*), and red cedar (*Juniperus virginiana*) are frequent in forested pastures. (pasture and hayland, forest, shrub savanna, tree savanna)

3. **Hayfields** - Planted in forage grasses and legumes, often Timothy (*Phleum pratense*) and alfalfa (*Medicago sativa*). These areas have less than 5% areal cover of woody vegetation and are mowed at least annually. (pasture and hayland)

4. **Agricultural land** - Agricultural fields planted to crops of grains, vegetables, silage, and fruits, *e.g.,* corn, soybeans, wheat, oats, sorghum, sunflower, melons, apples, grapes. This includes temporarily fallow fields because of season (stubble in winter or wet, unplowed fields in spring) or rotation schedules. Agricultural fields dominated by weeds are also considered cropland, not forbland. Landscape nurseries with shrubs and sub-mature trees are included in this cover type. (cropland, orchard, and vineyard)

5. **Developed land** - Includes any land that has been highly modified or has structures built on it. Examples include residential and commercial areas, vacant urban lots, farm buildings, feedlots, schools, industrial buildings, county fair grounds, air strips, parking lots, junk yards, actively stripmined land, roadways, and cemeteries. (urban and built-up land, mining area)

6. **Fence row** - Linear strips of vegetation, which are most often found separating large tracts of cropland or forageland. Examples of this community class include fencelines composed of volunteer vegetation as well as planted hedgerows and shelterbelts, and woody railroad rights-of-way. Generally if a fencerow is greater than 15 m (50 ft) wide, it is mapped as upland forest or shrubland depending on growth habit of dominant vegetation. If the area vegetated is very narrow and does not provide wildlife habitat, the fence row may be mapped with the adjacent cover type. (forest, shrubland, or mapped with surrounding land, based on size of area)

7. **Shrubland** - Abandoned pastures, successional fields, and railroad or highway rights-of-way dominated by dense to open stands of shrubs and young trees, with at least 25% shrub cover. Common woody species are osage-orange (*Maclura pomifera*), honey-locust (*Gleditsia tricanthos*), shingle oak (*Quercus imbricaria*), slippery elm (*Ulmus rubra*), black locust (*Robinia pseudoacacia*), black cherry (*Prunus serotina*), red cedar (*Juniperus virginiana*), wild blackberry (*Rubus* spp.), coralberry (*Symphoricarpos orbiculatus*), multiflora rose (*Rosa multiflora*), hawthorn (*Crataegus* spp.), and hazelnut (*Corylus americana*). (shrubland)

8. **Non-native grassland** - Open land dominated by exotic cool-season grasses, especially smooth brome (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis*), and meadow fescue (*Festuca pratensis*). Some native, warm-season, disturbance-adapted grasses such as broom sedge (*Andropogon virginicus*), purple-top (*Tridens flavus*), dropseed (*Sporobolus asper*) and bead grass (*Paspalum* spp.) may be common or dominant within this cover type. Shrubs and forbs often are present, but not dominant. These areas are not used for pasture or hay, but are periodically mowed. This cover type includes grassways within cropland, some forest preserve land in urban areas, and wide infrequently mowed roadsides. Narrow strips of frequently mowed roadsides are not mapped under this cover type. (grassland, shrub savanna)

9. **Native grassland** (prairie) - This category includes prairie, wet prairie, sand prairie, gravel prairie, dolomite prairie, hill prairie, and shrub prairie. Native prairie found in project areas is usually degraded by fire suppression, herbicide spraying, and mowing, and is

found as remnant communities in roadsides, pastures, abandoned railroad rights-of-way, and cemeteries. Most of the sites consist of warm-season grasses and disturbance-tolerant forbs persisting amid shrub thickets and exotic grasses. This cover type also includes prairie restorations or successional sites dominated by native prairie grasses, with some native forbs present. (grassland, shrub savanna)

10. **Savanna** - Community that is characteristically bi-layered consisting of a ground cover of native grasses, forbs, sedges, and shrubs with an open canopy (10 to 80% closure) of fire-adapted tree species. Many savannas have succeeded to closed communities because of fire suppression and should be mapped as upland forest. Some grazed savannas have maintained their structure, but have lost their native herbaceous layer, and are considered pastures. (tree savanna)

11. **Upland forest** - This community type includes xeric, dry, dry-mesic, mesic and wet-mesic upland forest and sand forest, flatwoods, and successional forests occurring on sites not originally forested. These forests do not normally flood by stream overflow. Forests on terraces are considered upland forests, because by definition terraces do not flood. Disturbances typical to these communities are grazing, logging, and trash dumping and the degree and type of disturbance should be noted in the field. Riparian forests at the heads of streams, some flatwoods communities, and some forested seeps are included in this cover type. (forest, forested wetland)

12. **Tree plantation** - Planted by humans. Common plantations are composed of pine (*Pinus* spp.), black locust (*Robinia pseudoacacia*), and black walnut (*Juglans nigra*). (forest)

13. **Floodplain forest** - This community type includes wet and mesic forest. Located on floodplains of streams or in isolated depressions. The communities are determined by frequency and duration of flooding and by permeability of the soil. Riparian communities appearing to be well-drained, forest communities occurring on natural levees, and some flatwoods communities are included in this cover type. (forested wetland)

14. **Swamp** - Areas dominated by living trees with permanent or semi-permanent standing water. True swamps are limited to extreme southern Illinois. Dominants are tupelo gum (*Nyssa aquatica*), bald cypress (*Taxodium distichum*), and buttonbush (*Cephalanthus occidentalis*). (forested wetland)

15. **Wet shrubland** - Includes areas dominated (more than 25% areal cover) by woody vegetation less than 6 m (20 ft) tall. The species include true shrubs, and young trees or shrubs that are small or stunted because of environmental conditions. Includes shrub carr, shrub swamps, fens and bogs dominated by shrubs, and successional wetlands dominated by young trees and shrubs, especially willows (*Salix* spp.). (scrub-shrub wetland)

16. **Marsh** - Includes areas dominated by tall graminoid plants and that have water near or above the surface for most of the year. Soils may be peat, muck, or mineral. Dominant plants are cattail (*Typha* spp.), water smartweed (*Polygonum amphibium*), common reed (*Phragmites australis*), bulrush (*Scirpus* spp.), burreed (*Sparganium* spp.), and sweet flag (*Acorus calamus*). (herbaceous wetland)

17. **Sedge meadow** - Includes areas dominated by sedges (*Carex* spp.) on peat, muck, or wet sand. This community type is relatively homogeneous in composition and structure. Some floristic overlap occurs between this cover type and wet prairie. Dominants are tussock sedge (*Carex stricta*), bluejoint grass (*Calamagrostis canadensis*), and sedges (*Carex lacustris*; *C. lasiocarpa*). (herbaceous wetland)

18. **Wet meadow** - Includes areas dominated by grasses where soils are hydric. Sites are often disturbed sedge meadows or wet prairies and the ground surface may be uneven from old tussocks of tussock sedge (*Carex stricta*). The dominant plants are reed canary grass (*Phalaris arundinacea*) and red-top (*Agrostis alba*). Other common sites are disturbed urban areas where grasses have been planted and where wetland hydrology is present. (herbaceous wetland)

19. **Other uncommon hydrophytic plant communities** - This cover type includes bogs, fens, pannes, seeps, and springs. Bogs are usually found in glacial depressions with very poor drainage. They are restricted to northeastern Illinois. Fens are found on sites with peaty substrate and calcareous seepage. They are usually located in the northern third of Illinois extending down the Illinois River valley. Pannes are very restricted in Illinois and only occur in wet and wet-mesic swales in calcareous sand within 1.6 km (1 mile) of Lake Michigan. Seeps and springs occur where ground water flows to the surface and are usually forested. Seeps are often very small and springs do not support a well-developed plant community. (herbaceous wetland, scrub-shrub wetland, forested wetland)

20. **Pond** - These could be natural or artificial. Non-maintained ponds will support wetland vegetation around the periphery of the pond. Typical vegetation includes willow (*Salix* spp.), cattail (*Typha* spp.), reed canary grass (*Phalaris arundinacea*), sedge (*Carex* spp.), common reed (*Phragmites australis*), barnyard grass (*Echinochloa crusgalli*), and smartweed (*Polygonum* spp.). Maintained ponds are actively used farm ponds, sewage lagoons, brine ponds, ornamental ponds, and active quarry and mining ponds. Vegetation may be present or may have been removed by maintenance activities. (shore and bottom wetland)

21. **Lake** - Includes wetlands and deepwater habitats that are situated in a topographic depression or a dammed river channel, that lack trees, shrubs, persistent emergents, and where the total area exceeds 8 hectares (20 acres). These areas are permanently flooded lakes and reservoirs. Areas less than 8 hectares (20 acres) are also termed lakes if an active wave-formed or bedrock shoreline feature makes up all or part of the boundary or if the water in the deepest part of the basin exceeds 2 m (6.6 ft) at low water. (lacustrine)

22. **Stream** (river, permanent stream, intermittent stream) - Includes wetlands and deepwater habitats contained within a channel, except those dominated by trees, shrubs, or other persistent emergents, river, permanent stream, intermittent stream. The channel should periodically or continuously contain moving water, or form a connecting link between two bodies of standing water. Many are channelized and may resemble drainage ditches. (riverine)

23. **Drainage ditch** - Maintained by human activities, primarily located within cropland and along roadsides. (riverine, herbaceous wetland)

24. **Other uncommon upland plant communities** - This cover type includes glades, cliffs, and bluffs. Soil at these sites is thin or absent and the community is at an early stage of succession. A glade is an opening in the forest, usually with bedrock at or near the surface, and where vegetation is patchy and often stunted. Cliffs are vertical exposures of bedrock, and may be either sandstone or limestone. Bluffs are vertical exposures of eroded unconsolidated material or weak rock. The plant community is poorly developed because of continual slumping. (barren land, shrubland, forest, native grassland, tree savanna, shrub savanna)

25. **Barren land** - Land denuded by human activity, usually with less than 1% vegetation cover. Includes abandoned mining areas, recently scraped sites, and sites with severe erosion. (barren land)

Literature Cited

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. Office of Biological Services, Fish and Wildlife Service, U.S. Department of the Interior, Washington, DC. FWS/OBS-79-31. December.

U.S. Fish and Wildlife Service. 1980. Habitat evaluation procedure (HEP). U.S. Fish and Wildlife Service, Washington, DC. Ecological Services Manual 101.

White, J. 1978. Survey methods and results. Illinois Natural Areas Inventory, Urbana. Technical Report Volume 1. November.

Appendix F: Sample Wetland Project Documents

This appendix contains a Section 404 permit and the special provisions for wetland mitigation from a wetland plan prepared by the Illinois Department of Transportation. The project was conducted as compensation for wetland losses associated with replacement and construction of the IL Route 2 bridge over the Rock River. The planned wetland site is located near Grand Detour, IL, west of IL Route 2 and north of the Rock River.

DEPARTMENT OF THE ARMY PERMIT

Permit Number: CENCR-OD-S-070-0X6-1-203410 Section: 404

Permittee: Illinois Department of Transportation
Division of Highways, District 2,
819 Depot Avenue
Dixon, Illinois 61021-3500

POC: Mr. Larry Hill
Tel: 815/284-5450

Effective Date: 21 August 1991

Expiration Date: 31 December 1995

Issuing Office: U.S. Army Corps of Engineers, Rock Island District
Clock Tower Building - P.O. Box 2004
Rock Island, Illinois 61204-2004

You are authorized to perform work in accordance with the terms and conditions specified below.

NOTE: The term "you" and its derivatives, as used in this permit, means the permittee or any future transferee. The term "this office" refers to the appropriate district or division office of the Corps of Engineers having jurisdiction over the permitted activity or the appropriate official of that office acting under the authority of the commanding officer.

Project Description: The permittee will replace an existing bridge crossing the Rock River and make roadway improvements to Illinois Route 2. The purpose of the project is to replace a bridge which has deteriorated to the point of requiring extensive maintenance and to upgrade a segment of Illinois Route 2 which has a persistently high accident rate. A new 1,000-foot-long, 40-foot-wide plate girder bridge will be constructed on the upstream side of the existing bridge. New roadway approaches to the bridge and new access roadways into Grand Detour, Illinois and into Castle Rock State Park will also be constructed. These roadways will result in the loss of approximately 3.5 acres of forested wetland. The permittee will compensate for the impacts to wetland areas by creating a 5.3 acre wetland east of the new bridge location.

Project Location: Rock River and adjacent wetlands, approximate river mile 97.6, in Section 13, Township 22 North, Range 9 East, and in Section 20, Township 23 North, Range 10 East, near Grand Detour, in Ogle County, Illinois.

in accordance with the plans and drawings attached hereto which are incorporated in and made a part of this permit.

Drawings No. 203410. Sheet 1 of 6, Location Map
Sheet 2 of 6, Plan View
Sheet 3 of 6, Cross Section
Sheet 4 of 6, Cross Section
Sheet 5 of 6, Plan View
Sheet 6 of 6, Plan View

Permit Conditions:

General Conditions:

1. The time limit for completing the work authorized ends on the date specified on page 1. If you find that you need more time to complete the authorized activity, submit your request for a time extension to this office for consideration at least one month before that date is reached.

2. You must maintain the activity authorized by this permit in good condition and in conformance with the terms and conditions of this permit. You are not relieved of this requirement if you abandon the permitted activity, although you may make a good faith transfer to a third party, in compliance with General Condition 4 below. Should you wish to cease to maintain the authorized activity or should you desire to abandon it without a good faith transfer, you must obtain a modification of this permit from this office, which may require restoration of the area.

3. If you discover any previously unknown historic or archaeological remains while accomplishing the activity authorized by this permit, you must immediately notify this office of what you have found. We will initiate the Federal and state coordination required to determine if the remains warrant a recovery effort or if the site is eligible for listing in the National Register of Historic Places.

4. If you sell the property associated with this permit, you must obtain the signature of the new owner in the space provided and forward a copy of the permit to this office to validate the transfer of this authorization.

5. If a conditioned water quality certification has been issued for your project, you must comply with the conditions specified in the certification as special conditions to this permit. For your convenience, a copy of the certification is attached if it contains such conditions. (Condition is not applicable for Section 10 Permits.)

6. You must allow representatives from this office to inspect the authorized activity at any time deemed necessary to ensure that it is being or has been accomplished in accordance with the terms and conditions of your permit.

Special Conditions:

1. That conditions 1 thru 5 listed in the attached letters from the Illinois Environmental Protection Agency, Log #C-266-91 dated May 8, 1991, are considered to be part of this permit.

2. That a 5.3 acre wetland mitigation area consisting of floodplain forested habitat will be created as shown in the wetland mitigation plan drawing in this permit. The mitigation plan shall be implemented during the time of the bridge construction activities and shall be completed within one year after the bridge construction and roadway realignment work.

3. That the applicant will maintain a minimum of 80 percent survival rate of the tree and shrubs seedlings planted in the wetland mitigation site for a period of three years.

4. That the applicant will provide this office with yearly monitoring reports as to the desirability of the wetland mitigation site. Should deficiencies be uncovered during these yearly review procedures, additional corrective actions may be necessary to correct any deficiencies noted.

Further Information:

1. Congressional Authorities: You have been authorized to undertake the activity described above pursuant to:

( ) Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403).

(X) Section 404 of the Clean Water Act (33 U.S.C. 1344).

( ) Section 103 of the Marine Protection, Research and Sanctuaries Act of 1972 (33 U.S.C. 1413).

2. Limits of this authorization.

a. This permit does not obviate the need to obtain other Federal, state, or local authorizations required by law.

b. This permit does not grant any property rights or exclusive privileges.

c. This permit does not authorize any injury to the property or rights of others.

d. This permit does not authorize interference with any existing or proposed Federal project.

3. Limits of Federal Liability. In issuing this permit, the Federal Government does not assume any liability for the following:

a. Damages to the permitted project or uses thereof as a result of other permitted or unpermitted activities or from natural causes.

b. Damages to the permitted project or uses thereof as a result of current or future activities undertaken by or on behalf of the United States in the public interest.

c. Damages to persons, property, or to other permitted or unpermitted activities or structures caused by the activity authorized by this permit.

d. Design or construction deficiencies associated with the permitted work.

e. Damage claims associated with any future modification, suspension, or revocation of this permit.

4. Reliance on Applicant's Data: The determination of this office that issuance of this permit is not contrary to the public interest was made in reliance on the information you provided.

5. Reevaluation of Permit Decision. This office may reevaluate its decision on this permit at any time the circumstances warrant. Circumstances that could require a reevaluation include, but are not limited to, the following:

a. You fail to comply with the terms and conditions of this permit.

b. The information provided by you in support of your permit application proves to have been false, incomplete, or inaccurate (See 4 above).

c. Significant new information surfaces which this office did not consider in reaching the original public interest decision.

Such a reevaluation may result in a determination that it is appropriate to use the suspension, modification, and revocation procedures contained in 33 CFR 325.7 or enforcement procedures such as those contained in 33 CFR 326.4 and 326.5. The referenced enforcement procedures provide for the issuance of an administrative order requiring you to comply with the terms and conditions of your permit and for the initiation of legal action where appropriate. You will be required to pay for any corrective measures ordered by this office, and if you fail to comply with such directive, this office may in certain situations (such as those specified in 33 CFR 209.170) accomplish the corrective measures by contract or otherwise and bill you for the cost.

6. Extensions. General condition 1 establishes a time limit for the completion of the activity authorized by this permit. Unless there are circumstances requiring either a prompt completion of the authorized activity or a reevaluation of the public interest decision, the Corps will normally give favorable consideration to a request for an extension of this time limit.

Your signature below, as permittee, indicates that you accept and agree to comply with the terms and conditions of this permit.

William D. Oster
Permittee

Aug. 12, 1991
Date

This permit becomes effective when the Federal official, designated to act for the Secretary of the Army, has signed below.

for John R. Brown
Colonel, U.S. Army
District Engineer

8/21/91
Date

When the structures or work authorized by this permit are still in existence at the time the property is transferred, the terms and conditions of this permit will continue to be binding on the new owner(s) of the property. To validate the transfer of this permit and the associated liabilities associated with compliance with its terms and conditions, have the transferee sign and date below.

Transferee

Date

Illinois Environmental Protection Agency · P. O. Box 19276, Springfield, IL 62794-9276

217/782-0610

Illinois Dept. of Transportation (Ogle County) Bridge Replacement (Rock River)
Log No. C-266-91 (CoE Appl. 203410)

May 8, 1991

Mr. James H. Blanchar, P.E.
Chief, Operations Division
Rock Island District
Corps of Engineers
Clock Tower Building
Rock Island, Illinois 61201

Dear Mr. Blanchar:

This Agency received a request on May 2, 1991, from the Illinois Department of Transportation requesting necessary comments for environmental consideration concerning the replacement of an existing bridge over the Rock River and accompanying highway improvements on Illinois Route 2 near Grand Detour, Ogle County, Illinois. Approximately 3.7 acres of forested wetland will be lost which will be mitigated by the creation of a 5.5 acre wetland east of the new bridge. We offer the following comments.

Based on the information included in this submittal, it is our engineering judgment that the proposed project may be completed without causing water pollution as defined in the Illinois Environmental Protection Act, provided the project is carefully planned and supervised.

These comments are directed at the effect on water quality of the construction procedures involved in the above described project and is <u>not</u> an approval of any discharge resulting from the completed facility, nor an approval of the design of the facility. These comments do <u>not</u> supplant any permit responsibilities of the applicant towards this Agency.

This Agency hereby issues certification under Section 401 of the Clean Water Act (PL 95-217), subject to the applicant's compliance with the following conditions:

1. The applicant shall not cause:

    a. violation of applicable water quality standards of the Illinois Pollution Control Board, Title 35, Subtitle C: Water Pollution Rules and Regulations;

    b. water pollution as defined and prohibited by the Illinois Environmental Protection Act; and

    c. interference with water use practices near public recreation areas or water supply intakes.

Illinois Environmental Protection Agency · P. O. Box 19276, Springfield, IL 62794-9276

Page 2

2. The applicant shall provide adequate planning and supervision during the project construction period for implementing construction methods, processes and cleanup procedures necessary to prevent water pollution and control erosion.

3. Any spoil material excavated, dredged or otherwise produced must not be returned to the waterway but must be deposited in a self-contained area in compliance with all State statutes, regulations and permit requirements with no discharge to the waters of the State unless a permit has been issued by this Agency. Any back filling must be done with clean material and placed in a manner to prevent violation of applicable water quality standards.

4. All areas affected by construction shall be mulched and seeded as soon after construction as possible. The applicant shall undertake necessary measures and procedures to reduce erosion during construction. Interim measures to prevent erosion during construction shall be taken and may include the installation of staked straw bales, sedimentation basins and temporary mulching. All construction within the waterway shall be conducted during zero or low flow conditions.

5. The applicant shall implement erosion control measures consistent with the "Standards and Specifications for Soil Erosion and Sediment Control" (IEPA/WPC/87-012).

6. This certification becomes effective when the Department of the Army, Corps of Engineers, includes the above conditions #1 through 5 as conditions of the requested permit issued pursuant to Section 404 of PL. 95-217.

This certification does not grant immunity from any enforcement action found necessary by this Agency to meet its responsibilities in prevention, abatement, and control of water pollution.

Very truly yours,

Thomas G. McSwiggin by [illegible] Keller

Thomas G. McSwiggin, P.E.
Manager, Permit Section
Division of Water Pollution Control

TGM:JH:ct,1388q,51-52

cc: IEPA, DWPC, Records Unit
DWPC, Field Operations Section, Region 1
IDOT, Division of Water Resources, Springfield
USEPA, Region V
Illinois Dept. of Transportation

May 11, 1993

WETLAND MITIGATION
IL 2 - Grand Detour Bridge

The following Special Provisions pertain to the Wetland Mitigation Site.

EARTH EXCAVATION

Effective March 29, 1993

This item involves excavating the wetland mitigation area in the specific areas and shapes as indicated in the plans or as directed by the Engineer. The wetland mitigation area is shown on the plans and will be constructed as follows:

Construction Requirements - Aquatic Emergent Wetland Configuration: The Aquatic Emergent Wetland area shall begin at the edge of the construction limits as shown on the plans and slope at a ratio of 6:1 to an elevation of 649.2 feet then slope at a 30:1 ratio to the bottom of the wetland. On the north side, the ground shall slope up out of the Aquatic Emergent Wetland at a 30:1 ratio to an elevation of 649.2 and then slope at 6:1 up to the Floodplain Forest elevation. The shoreline of the excavation must not be straight, but shall be curvilinear to provide the maximum amount of aquatic/terrestrial edge. The Aquatic Emergent Wetland mitigation site shall be finished to elevation 648.2 and variable (about 8 inches below the water table) as shown on the plans.

The banks of the excavation shall not have a slope steeper than 6:1. No earth excavation shall take place outside the construction limits to avoid impacts to the tree root systems.

Construction Requirements - Floodplain Forest Configuration: The Floodplain Forest shall begin at the edge of the Aquatic Emergent Wetland to the south and the construction limits on all other sides as shown on the plans. It shall slope down from the construction limits at a ratio of 6:1 to an elevation of 652.0 feet then slope at a 30:1 ratio to the bottom of the Floodplain Forest. On the west side, the ground shall slope at a 30:1 ratio up to the construction limits as shown on the plans. The shoreline of the excavation must not be straight, but shall be curvilinear to provide the maximum amount of aquatic/terrestrial edge. The Floodplain Forest site shall be finished to elevation 651.0 (about 2 feet above the water table) as shown in the plans.

May 11, 1993

The banks of the excavation shall not have a slope steeper than 6:1. No earth excavation shall take place outside the construction limits to avoid impacts to the tree root systems.

Construction Requirements - Berm Configuration: The Earth Berm shall begin at the northwest edge of the Floodplain Forest as shown on the plans. The Berm shall slope up from the natural ground elevation at a 2:1 ratio (and at a 4:1 ratio at each end) to an elevation of 663.9 feet (which is 2 feet above the 100-year natural highwater). The top of the Berm shall be approximately 8 feet wide. The fill material for the Berm shall consist of earth. Stone Riprap Class A5 shall be placed on the river side and at each end of the Berm to an elevation of 660.0 feet as shown on the plans. A 10-foot to 15-foot-wide access area (road) shall be provided on all sides of the base of the Berm to provide for Berm maintenance.

Construction Requirements - Access Road: During construction, an Access Road shall be constructed as a dirt road from the field entrance west of the Illinois 2 right-of-way (Left existing Station 243+00) to the wetland baseline as shown on the plans. After construction of the wetland is completed, the Access Road shall be finished with Aggregate Base Course Type B, 8" as shown on the plans.

Construction Requirements - Overflow Channel: An Overflow Channel shall be constructed at the southwest side of the site as shown on the plans. The control elevation of the Channel will be 649.2. This channel will not be opened to water flow until all of the seeding and planting has been completed. A 30x40 foot area of Stone Riprap Class A3 will be placed as shown on the plans to allow vehicle access across the channel. The channel shall taper from the edge of the wetland to the river. It will have a 10-foot bottom width throughout its length. There will be 8:1 side slopes between the edge of the wetland to approximately 150 feet south of the wetland. The remaining portion will have 3:1 side slopes to avoid impacts to tree root systems.

This work shall be paid for at the contract unit price per Cubic Yard of EARTH EXCAVATION.

TOPSOIL PLACEMENT 6", TOPSOIL EXCAVATION

Effective March 29, 1993

This work shall be done in accordance with applicable portions of Section 216 of the Standard Specifications and shall be applied to all areas designated on the plans or specifications.

The top 2.0 feet (maximum) of topsoil shall be removed from within the Aquatic Emergent Wetland construction limits of the mitigation site at the beginning of construction and stockpiled, as shown on the plans. The topsoil shall not be stockpiled on any tree root systems (defined by the drip lines) or in any existing wetland. This soil shall then be used for topsoil placement on the berm and on the Illinois 2 mainline as designated on the plans. The topsoil shall be placed on the berm to a depth of 6 inches to the final elevations shown on the plans. The mainline areas shall receive topsoil placement per depth shown on the plans.

May 11, 1993

Basis of Payment: This work shall be paid for at the contract unit price for TOPSOIL PLACEMENT 6" and shall include the cost of placing of the topsoil. The excavation will be measured and paid for as TOPSOIL EXCAVATION and will include the cost of stockpiling.

HYDRIC TOPSOIL PLACEMENT 6", TOPSOIL EXCAVATION

Effective March 29, 1993

This work shall be done in accordance with applicable portions of Section 216 of the Standard Specifications and shall be applied to all areas designated on the plans or specifications.

Hydric Topsoil totalling 10,120 cubic yards shall be defined as a topsoil removed from the proposed Illinois 2 mainline between Stations 1238+00 and 1250+00 to a maximum depth of 4.0 feet as shown on the plans. This shall be stockpiled separately from normal topsoil. This topsoil shall not be stockpiled on any tree root systems (defined by the drip lines) or in any existing wetland.

This soil shall then be used for hydric topsoil placement. The hydric topsoil shall be placed over the areas labeled Aquatic Emergent Wetland, Floodplain Forest, and Wet Prairie (a total of 10.2 acres) to a depth of 6 inches to the final elevations shown on the plans.

Basis of Payment: This work shall be paid for at the contract unit price for HYDRIC TOPSOIL PLACEMENT 6" and shall include the cost of placing and hauling of the topsoil. The excavation will be measured and paid for as HYDRIC TOPSOIL EXCAVATION and will include the cost of stockpiling.

SEEDING CLASS 7 (SPECIAL)

Effective March 29, 1993

This work shall be done in accordance with applicable portions of Section 642 of the Standard Specificatons and shall be applied to all areas, designated on the plans or specifications, of the Wetland Mitigation Area.

All exposed surfaces will be seeded to Seeding Class 7 (Special). This is a maximum of 13.3 acres (4.3 acres is contingent upon dry soil conditions). If the Aquatic Emergent Wetland Area (4.3 acres) is covered with water as soon as it is excavated, then it will not be seeded with Seeding Class 7 (Special). If the Aquatic Emergent area is dry, then Seeding Class 7 (Special) shall be seeded.

Seeding Class 7 (Special) shall consist of the following:

Common Name	Quantity/Acre
Oats	64 lb.
Annual Rye	10 lb.
Timothy	2 lb.

Seeding Time: Seeding Class 7 (Special) will be sown for erosion control as soon as all of the earth is excavated from the site and the specified grading and shaping are completed. Mulching shall be the same as for Class 6.

May 11, 1993

Method of Measurement: Seeding Class 7 (Special) shall be measured as specified in Article 642.09 of the Standard Specifications, in acres of surface area seeded.

Basis of Payment: Seeding Class 7 (Special) measured as provided above, will be paid for at the contract unit price per Acre of SEEDING CLASS 7 (SPECIAL) as specified.

WETLAND ROOTSTOCK

Effective March 29, 1993

This work shall consist of preparing planting beds; and furnishing and planting herbaceous wetland plants of the species specified, complete and in place at the locations and in the patterns designated on the plans or as directed by the District 2 Landscape Architect or Staff Ecologist; and fabrication and placement of the Preditor Protection System as described below. The Wetland Rootstock Plantings will be planted in the Aquatic Emergent Wetland Area, including the 30:1 slopes (4.3 acres). Revegetation of the project site shall be carried out by the Contractor according to the Standard Specifications (where applicable) and the following Special Provisions.

Materials: Wetland plants shall consist of rhizomes (roots), tubers, sprigs, or plugs of the species listed in Table 1. Each plant shall possess at least one viable shoot or growing point capable of initiating above ground growth. Plugs are cubes or cylinders of soil containing crowns, stems, roots and rhizomes. The diameter of plugs shall be 4 inches or more; depth shall be sufficient to contain rhizomes and the majority of the fibrous root system. Entire plugs shall be used as planting units.

Green aerial growing shoots when present shall be trimmed to within 3 inches above the growing point before being transplanted.

Sources of Plant Materials: Plant materials shall be obtained from within the region (i.e., northern Illinois, southern Wisconsin, or eastern Iowa) and shall consist of local regional ecotypes (species which are adapted to the environmental conditions of the area) true to name and hardy under the climatic conditions at the work site. Unless otherwise specified, plants shall be obtained from and planted by a licensed nursery which normally handles or has expertise in handling native wetland plant materials. Material shall be free from weed species that would be undesirable at the worksite and shall be dug, handled and stored with care and skill to prevent injury due to molding, rotting, or drying. Planting will be completed by one of the four companies listed below or by another qualified company as approved by the District 2 Landscape Architect or Staff Ecologist:

Genesis Nursery, Inc.
R. R. 1, Box 32
Walnut, IL 61376
(815/379-9060)

LaFayette Home Nursery, Inc.
LaFayette, IL 61449
309/995-3311
(708/584-0150)

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Country Wetlands Nursery & Consulting, LTD
575 W20755 Field Drive
Muskego, WI 53150
(414/679-1268)

The Natural Garden
38W443 Highway 64
St. Charles, IL 60174
(708/584-0150)

Assurance of Material Availability: Several species required under this item may not be readily available, and significant lead time will be necessary in order to obtain the specified quantities. It is recommended that the Contractor notify the nursery approximately one year in advance of the estimated planting time. The Contractor shall submit a written plan to the Engineer for the planting, outlining the source(s) for the specified quantities and species of wetland plants. The planting plan shall be submitted by August 1 of the preceeding year. Plans shall include evidence ensuring that the specified materials have been reserved and/or secured for use on the project. This plan shall be subject to approval by the District 2 Landscape Architect or Staff Ecologist.

Substitution: Where evidence is submitted that a specified plant cannot be obtained, substitution may be made upon approval of the District 2 Landscape Architect or Staff Ecologist.

Plant Approval: All plant material shall be subject to the approval of the District 2 Landscape Architect or Staff Ecologist. Plants shall be true to name and conform to all other specifications. Plant material may be inspected at the grower's nursery. Approval of plants at the source does not alter the right of rejection at the project site.

All plant material shall be dug and handled with care and skill to prevent injuries, and shall be packed in an approved manner to ensure arrival at the project site in good condition. Such material shall be kept moist and cool and shall show no evidence of injury, molding, rotting or drying directly prior to planting.

All plants rejected at the project site shall be replaced with acceptable plants of the same species unless directed by the District 2 Landscape Architect or Staff Ecologist.

TABLE 1
Wetland Rootstock Plantings
(For Aquatic Emergent Wetland Area - Elevation 648.2 to 649.2 Feet)

Common Name	Botanical Name	# of Plants (for 4.3 Ac.)
Water Plantain	*Alisma plantago-aquatica*	620
Bluejoint grass	*Calamagrostis canadensis*	620
Marsh Marigold	*Caltha palustris*	620
Lake Sedge	*Carex lacustris*	820
Woolly Sedge	*Carex lanuginosa*	820
Tussock Sedge	*Carex stricta*	820
Spike Rush	*Eleocharis obtusa*	820
Blue Flag Iris	*Iris virginica shrevei*	620
Marsh Smartweed	*Polygonum amphibium*	620

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Common Arrowleaf	Sagittaria latifolia	580
Arrowhead	Sagittaria rigida	620
Hardstem Bulrush	Scirpus acutus	720
Wool Grass	Scirpus cyperinus	820
River Bulrush	Scirpus fluviatilis	820
Soft-stem Bulrush	Scirpus validus	720
Burreed	Sparganium eurycarpum	720
Cordgrass	Spartina pectinata	620

Planting Zones: The wetland planting zones (Aquatic Emergent Wetland, Wet Prairie, and Floodplain Forest) are to be located as defined in the plans and shall be marked in the field as directed by the Engineer.

Planting Time: Wetland plant materials shall be transplanted between March 1 and April 30. Any other planting time shall require written permission of the District 2 Landscape Architect or Staff Ecologist. Unless otherwise approved, planting shall not take place when the ground or overlying water is frozen or when conditions are otherwise unsatisfactory for planting.

Preparation of Planting Area: Grading and backfilling, when called for in the contract, shall be completed before placement of plant materials in order to provide a suitable substrate for growth. Areas above water level shall be worked with discs, harrows or other appropriate equipment only as necessary to obtain a reasonably even, loose and weed-free substrate immediately in advance of the planting.

Delivery and Temporary Storage: At least 5 days prior to each delivery of plant material to the storing or project site, the Contractor shall notify the District 2 Landscape Architect or Staff Ecologist of such contemplated delivery.

Insofar as practicable, transplanting of rootstocks shall occur on the day of delivery at the project site. In the event this is not possible, the plants shall be temporarily stored in a well-ventilated, cool storage place and shall be adequately protected against drying. This storage period shall not exceed 48 hours for any rootstocks.

Any previously accepted plant material that has become damaged during on-site storage shall be replaced by the Contractor.

Planting Layout: Planting zone boundaries shall be shown on the plans and marked in the field as directed by the Engineer or the District 2 Landscape Architect. Zones will be delineated according to the elevations shown in the plans. Rootstocks shall be planted in the Aquatic Emergent Wetland Area as shown on the plans. The species listed in Table 1 shall be planted in this zone as described. No rootstock shall be planted under more than 1.5 feet of water.

The planting pattern will be centered on 15-foot grid points. At each grid area (or planting bed) three rows of 5 to 6 tubers each (15-18 tubers per grid point) shall be planted at a 1- to 1.5-foot spacing. The Contractor shall, by staking or flagging within the Aquatic Emergent Wetland Area, directed by the District 2 Landscape Architect or Staff Ecologist, establish this grid system to ensure that a uniform distribution of plantings is made. A total of 12,000 rootstocks shall be planted in this area.

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<u>Planting Method</u>: Tubers and rhizomes lacking or with limited fibrous root systems may simply be pushed into areas with soft substrates. In firmer substrates, planting holes shall be opened with dibbles, spades or other suitable tools. The exact procedure shall be dictated by soil texture and shall be approved by the District 2 Landscape Architect or Staff Ecologist.

Plants shall be transplanted in their natural orientation one to four inches deep or as specified by the supplier. Holes shall be made large enough to accommodate roots spread out to their approximate natural position. Each plant shall be so set in the ground, after the planting hole is closed and soil firmed around the plant, that it will stand at approximately the same depth it stood in the nursery or field.

End stakes or flags designating planting rows shall be left in place as markers to prevent damage to the plantings during subsequent seeding activities. The stakes or flags shall be removed upon completion of the seeding.

<u>Preditor Protection</u>: For preditor protection, each rectangular grid pattern will be covered with a 6'x 4' piece of one-inch hexagonical woven wire mesh (chicken wire) immediately after planting. An edge which is about 6 inches wide shall be folded downward around the perimeter of the entire piece. Then the piece shall be laid on top of the plantings and the edges pushed into the ground to secure it. If soil will not accommodate the pushing of the edges of the wire into the ground, the ends shall be secured with staples (Article 717.09(b)) at the rate of one per 3 feet of length.

<u>Care</u>: Freshly planted rootstock and new growth shall not be disturbed by subsequent activities that would cause uprooting, displacement or injury. During periods of intense heat or subnormal rainfall, supplemental watering may be required in accordance with the applicable requirements of Section 644.09 of the Standard Specifications.

<u>Method of Measurement</u>: Wetland Rootstock Plantings will be measured by the number of units of plants complete in place and accepted in accordance with the terms of this item. One unit of plants is equal to 1,000 plants.

<u>Basis of Payment</u>: All costs incurred in complying with this Special Provision shall be included in the cost for Unit of WETLAND ROOTSTOCK, which price shall be payment in full for preparing the planting area; for furnishing, transporting, handling, storing, and placing plant materials; and for furnishing all labor, tools, equipment and incidentals necessary to complete the work, <u>including the placement of the preditor protection system</u>.

<u>WET PRAIRIE SEEDING (SPECIAL)</u>

Seed shall be planted in the Wet Prairie Areas. The Wet Prairie Area is located on the 6:1 slopes and in the Overflow Channel. The work shall consist of preparing the seed bed, furnishing and sowing the required seed mixture on the Wet Prairie Areas as shown in the plans or as directed by the District 2 Landscape Architect or Staff Ecologist in accordance with the applicable requirements of Section 642 of the Standard Specifications and as hereinafter provided.

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Materials: This seed mixture will be referred to as "Wet Prairie Seeding (Special)" in the plans and contract. Seed shall be true to species name as specified below and shall not be used on the work later than one year after the date of collection. Seed shall be free from non-native weed seeds and reasonably free from large quantities of chaff and other non-seed plant debris, and shall not be enclosed in pods or fleshy hulls. Seed shall be harvested when ripe and shall be properly stratified if stored.

Seed Mixture Composition: The Wet Prairie Seeding (Special) seed mixture shall be composed of species from Table 2, as available. Amounts of each species are shown in the table. Other species adapted to the hydrologic regime at the work site and native to northern Illinois, southern Wisconsin, or eastern Iowa may be added or substituted with written approval of the District 2 Landscape Architect or Staff Ecologist.

TABLE 2
Wet Prairie Seeding (Special) Seeding Mixture
(for Wet Prairie Areas)

Common Name	Botanical Name	Amount To Be Planted (for 1.6 Acre)
Angelica	Angelica atropurpurea	27.0 oz.
Swamp Milkweed	Asclepias incarnata	4.5 oz.
New England Aster	Aster novae-angliae	4.5 oz.
Swamp Aster	Aster puniceus	4.5 oz.
Blue Joint Grass	Calamagrostis canadensis	2.3 oz.
Water Sedge	Carex aquatilis	9.0 oz.
Bottlebrush Sedge	Carex hystricina	13.5 oz.
Lake Sedge	Carex lacustris	9.0 oz.
Wooly Sedge	Carex lanuginosa	9.0 oz.
Red-rooted Sedge	Cyperus erythrorhizos	9.0 oz.
Tussock Sedge	Carex stricta	9.0 oz.
Joe Pye Weed	Eupatorium maculatum	4.5 oz.
Boneset	Eupatorium perfoliatum	4.5 oz.
Jewelweed	Impatiens capensis	9.0 oz.
Rice Cut Grass	Leersia oryzoides	9.0 oz.
Cardinal Flower	Lobelia cardinalis	9.0 oz.
Great Blue Lobelia	Lobelia siphilitica	9.0 oz.
Mountain Mint	Pycanthemum tenuifolium	2.3 oz.
Dark-green Rush	Scirpus atrovirens	18.0 oz.
Cup Plant	Silphium perfoliatum	9.0 oz.
Riddell's Goldenrod	Solidago riddellii	2.3 oz.
Blue Vervain	Verbena hastata	4.5 oz.
Iron Weed	Vernonia fasciculata	4.5 oz.
Wild Rye	Elymus canadensis	3.0 lb. PLS*
Oats	Avena sativa	48.0 lb.

*PLS = Pure Live Seed

Sources of Seed: Seed (with the exception of seed oats) shall be obtained from sources within the region (i.e., northern Illinois, southern Wisconsin, or eastern Iowa) of the work site and shall consist of local regional ecotypes

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hardy under the climatic conditions at the work site. Unless otherwise specified, seed shall be obtained from and planted by a licensed nursery or seed company, from the previous list, which normally handles or has expertise in handling native species.

Assurance of Seed Availability: Species required under this item may not be readily available, and significant lead time will be necessary in order to obtain the specified quantities. It is recommended that the Contractor notify the nursery approximately one year in advance of the estimated planting time. The Contractor shall submit a written plan to the Engineer for each seeding, outlining the source(s) for the specified quantities and species of seed. The planting plan for a given year shall be submitted by August 1 of the preceeding year. Plans shall include sufficient evidence ensuring that the specified seed has been reserved and/or secured for use on the project. Sources must be identified. This plan shall be subject to approval by the District 2 Landscape Architect or Staff Ecologist.

Seeding Zones: Wet Prairie Seeding (Special) Seeding Mixture shall be sown in all portions of the Wet Prairie Areas and planted after the rootstocks are in place. These areas are defined in the plans. Seeding zone boundaries and the extent of Wet Prairie Seeding (Special) shall be as determined by the Engineer or the District 2 Landscape Architect.

Seeding Time: Wet Prairie Seeding (Special) Seeding shall be sown between March 1 and May 15. Any other planting time shall require approval by the District 2 Landscape Architect or Staff Ecologist. Sowing shall not take place when the ground is frozen or when conditions are otherwise unsatisfactory for planting.

Seeding Rate: The specified seed mixture shall be sown at the rate of the specified number of pounds or ounces as indicated in Table 2.

Sowing Method - Wet Prairie Area: The Wet Prairie may be seeded by a hydraulic seeder or with a rangeland type grass drill (i.e., Nisbet, Truax, or John Deere, or other suitable equipment) meeting the approval of the District 2 Staff Ecologist or District Landscape Architect, or this area may be seeded by hand broadcasting the seed as described below. If a hydraulic seeder is used the planting procedure shall be followed according to Article 642.06(a) of the Standard Specifications. If seed is hand broadcast, seed shall be well mixed and broadcast evenly over the designated area. Wet seeds may be mixed with dry sand to aid in more even distribution.

Care: Freshly sown seed shall not be disturbed by subsequent activities that would cause displacement or uprooting.

Method of Measurement: Wet Prairie Seeding (Special) shall be measured as specified in Article 642.09 of the Standard Specifications, in acres of surface area seeded.

Basis of Payment: Wet Prairie Seeding (Special) measured as provided above, will be paid for at the contract unit price per Acre of WET PRAIRIE SEEDING (SPECIAL) at the specified rates of pounds or ounces of seeds as listed in Table 2. Note: The cost includes preparing the seed bed, furnishing, and sowing the required seed mixture on the Wet Prairie Area 5.

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SEEDING CLASS 4 (SPECIAL)

This work shall consist of preparing seed beds; furnishing; and sowing the specified Seeding Class 4 (Special) mixture on the following: the earth berm area above the 6:1 slope, the access road around the berm, the 15-foot area between the construction limits and the existing trees, and the right-of-way along side the access road, as shown on the plans or as directed by the District 2 Landscape Architect or Staff Ecologist; and maintenance of the seeded areas during the first growing season, in accordance with the applicable requirements of Section 642 of the Standard Specifications except as hereinafter provided.

Materials: The seed specified below (with the exception of seed oats) shall consist of local ecotypes obtained from sources within the region (i.e., northern Illinois, southern Wisconsin, or eastern Iowa), and shall consist of native rather than horticultural varieties. The vendor shall provide certification in writing that the species provided are true to name and of the purity specified below. Grass seed shall be reasonably free from large amounts of chaff and other non-seed debris. Seed shall be harvested when ripe, with care and skill, and shall not be used on the work later than one year after collection.

Seed Mixture Composition: The Seeding Class 4 (Special) seed mixture shall be composed of species from Table 3, as available. Amounts of each species are shown in the table. Other species adapted to the hydrologic regime at the work site and native to northern Illinois, southern Wisconsin, or eastern Iowa may be added or substituted with the written approval of the District 2 Landscape Architect or Staff Ecologist.

TABLE 3

Seeding Class 4 (Special)
(For Native Prairie Areas - On the berm, above the 6:1 slope, and along the access road)

Common Name	Botanical Name	To Be Planted (for 3.1 Acres)
Big Bluestem	*Andropogon gerardii*	12.0 lb. PLS *
Little Bluestem	*Schizachyrium scoparium*	15.0 lb. PLS
Prairie Switchgrass	*Panicum virgatum*	4.0 lb. PLS
Indian Grass	*Sorghastrum nutans*	6.0 lb. PLS
Prairie Bottlebrush Grass	*Hystrix patula*	1.0 lb. PLS
June Grass	*Koeleria macrantha*	3.0 lb. PLS
Side Oats Grama	*Bouteloua curtipendula*	15.0 lb. PLS
Wild Rye	*Elymus canadensis*	3.0 lb. PLS
Oats	*Avena sativa*	96.0 lb.

* PLS= Pure Live Seed

Sources of Seed: Seed (with the exception of seed oats) shall be obtained from sources within the region (i.e., northern Illinois, southern Wisconsin, or eastern Iowa) of the work site and shall consist of local regional ecotypes

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hardy under the climatic conditions at the work site. Unless otherwise specified, seed shall be obtained from and planted by a licensed nursery or seed company, from the previous list, which normally handles or has expertise in handling native species.

Seed Preparation: Seed shall be stratified and scarified by the vendor or the Contractor as necessary for maximizing the rate of germination. The grass mixture shall each be blended by the vendor and delivered to the work site.

Assurance of Material Availability: The materials specified in this item are commercially available in limited quantities. Vendors will need sufficient lead time in order to supply the specified quanatities. It is recommended that the Contractor notify the nursery approximately one year in advance of the estimated planting time. The contractor shall submit a written plan to the engineer providing sufficient evidence to ensure that seed of the species, variety and quantity specified has been reserved and/or secured for use on the project. The plan shall also include the intended source of these materials. The plan shall be submitted by August 1 of the preceeding year, and shall be subject to approval by the District 2 Landscape Architect or Staff Ecologist.

Seeding Time: Seeding Class 4 (Special) (as defined above) shall be sown on the berm area above the 6:1 slope and the access area around the berm, the 15-foot area between the construction limits and the existing trees, and the right-of-way along the access road as shown on the plans. The Seeding Class 4 (Special) seed mixture shall be sown between May 1 and June 15.

Seeding Rates: The specified seed mixture shall be sown at the rate of the specified number of pounds or ounces as indicated in Table 3.

Preparation of Seed Bed - Disturbed Areas: The seed bed shall be prepared according to Article 642.05 deleting references to fertilizing and adding the following provision. Before planting is to occur, two to three light diskings may be necessary to control unwanted vegetation prior to sowing whenever weeds reappear.

Sowing Method: (NOTE: Special equipment is required for native grass seeding.) Seed shall be well mixed and shall be sown immediately after final disking (if needed), using a hydraulic seeder; or it may be scattered (hand broadcast) uniformly over the areas to be seeded, and lightly raked or dragged to cover the seed with 1/4 to 1/2 inch of soil. If seed is planted with a hydraulic seeder, the instructions shall be followed according to the planting procedure described in Article 642.06(a) of the Standard Specifications. Seeding shall take place only at such times when the air movement is sufficiently low to prevent seeds from blowing away.

Care: Proper care of the seeding under this item shall consist of maintenance during the first growing season to encourage seedling establishment as follows. No herbicides or fertilizer shall be applied. Weeds shall be cut with a rotary mower when they have grown to a height of 10 to 12 inches (approximately one month after seeding) or before they set seed. Mowing height shall be 4 to 6 inches as appropriate to prevent damage to developing native seedlings. Weeds shall be cut similarly up to two additional times during the growing season whenever their height exceeds 12 inches.

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Method of Measurement: Seeding Class 4 (Special) will be measured in accordance with Article 642.09 of the Standard Specifications, in acres of surface area seeded.

Basis of Payment: All costs incurred in complying with this Special Provision shall be included in the unit price per Acre of SEEDING CLASS 4 (SPECIAL). Note: The cost includes preparing the seed bed, furnishing, sowing and caring for the required seed mixture on berm area, the 15-foot area between the construction limits and the existing trees, and the right-of-way along the access road.

FLOODPLAIN FOREST

PLANTING

Effective March 29, 1993

645.01 Description. This work shall consist of digging and preparing plant holes, and furnishing, transporting, and planting trees, shrubs, and other materials.

It shall also include all incidental operations such as mulching, wrapping (preditor protection), care of living plants, and replacement of unsatisfactory plants.

645.03 Planting Time. Add the following: "All plants shall be planted during the spring as defined.

Spring Planting. This work shall be performed from the time the soil can be worked until the plant, under field conditions, is not dormant except that bare root plant material shall be planted only when the air temperature exceeds 35°F."

645.08 Excavation of Plant Holes. Excavation for bare root shade trees and shrubs: Holes shall be dug at locations flagged. Hole diameters shall be 36 inches and hole depth shall be sufficient to permit two inches of the ball to be above the existing grade when planted. Holes for bare root trees shall be deep enough to accommodate the root system without cramping the roots, and allow the trees to be planted at the same depth they were growing in the nursery. The sides of holes shall not be glazed or smooth.

645.09 Pruning. Revise the first paragraph: "Qualified and trained personnel, experienced and familiar with accepted horticultural practices shall do all pruning as directed by the Engineer in a manner and method that will preserve and retain the growth habit and characteristic of the various individual plants."

645.10 Planting Procedures. Revise the first paragraph: "Prepared backfill shall not be required. The excavated material free of all vegetation shall be used as backfill and shall be in a loose friable condition."

Eliminate the second and third paragraphs.

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645.11 Mulch Cover. Revise to read: "A wood chip mulch four inches in depth shall be provided to all plants. This mulch shall cover the entire area excavated for the plant holes (as shown on the plans as Floodplain Forest). The following guidelines are provided:

> Bare root shade trees and shrubs shall be mulched to a depth of four inches in a circular pattern with 36-inch diameters measured from the center of the hole. These items will not require geotextile fabric."

645.13 Wrapping. Revise to read: "Within 7 days after planting all bare root shade tree trunks shall be wrapped from the ground line to a height of 3 feet with a one-half-inch square mesh, galvanized, steel wire with a minimum gauge of 19 (poultry netting) at a diameter of 14 inches measured from the center of the trunk with a 4-inch overlap. The screen wire shall be secured with a minimum of four steel staples (hog rings)." This will provide preditor protection.

645.14 Bracing. Delete.

645.18 Method of Measurement. Revise the second paragraph to read: "The excavation and disposal of excavated materials, wood chip mulch, tree wrapping, and care of the plants are incidental to the contract."

717.01 Materials for Planting. Add the following to (a) Quality of Plant Material part (1): "Plants shall have been growing a minimum of one year in the ground or container at the inspection location."

717.05 Mulch Material. Add the following:

"Wood Chip Mulch: Wood Chip Mulch shall consist of hardwood (deciduous) chips originating from tree trunks and larger limbs. It shall be free from bark, leaves, twigs, sawdust, foreign and extraneous matter, debris and toxic substances. Individual pieces shall not be smaller than one inch in the smallest dimension nor larger than one and three quarters inch in the largest dimension."

MULCH, METHOD 7

Effective March 29, 1993

This work shall be done in accordance with Section 643 of the Standard Specifications and shall be applied to all exposed surfaces above the proposed water elevation of 649.2 feet. This includes the Wet Prairie Area (1.6 acres) and the Seeding Class 4 Area (3.1 acres).

This work will be paid for at the contract unit price per Ton for MULCH, METHOD 7.

The items in the Wetland Mitigation Site Special Provision shall be paid for separately as described above.

Appendix G: Field Forms

The field forms contained in this appendix can be used to aid in conducting the Level 1 assessment and monitoring of soil, hydrogeology, vegetation, and wildlife. Refer to Chapter 2, "Site Assessment," and Chapter 5, "Monitoring Restored and Created Wetlands," for explanations of the forms.

Level 1 Soils Assessment

Site name:________________________________ Date: ____________

Location: Section (1/4, 1/4, 1/4)____________________ T.______R.______

County: ________________ Local address: ____________________

USGS quad:________________ NWI/IWI classification: ________________

Site size: (hectares/acres)

Weather conditions and recent trends: (ppt and amounts, temp., sky conditions). Data available from the State Climatologist at the Illinois State Water Survey. ____________________

____

Is aerial photography of site available? ______ yes ______no

Scale: ____ _ cm _ in = ____ _ m _ ft date of photo:

Is dark photo tone evident within or adjacent to the site? ______ yes ______ no

Is mapped soil on County or State hydric soils list? ______County ______State

Does the site contain soils classified as Prime Farmland? ____________________

Taxonomy of mapped soil (in table of County Soil Survey):____________________

____

Soil Series name: ____________________

Is site on lowest part of the local landscape? ______ yes ______ no

Is site adjacent to a source of water? yes ______ no ______

Type: _ intermittent stream _ perennial stream _ other Describe:

____

Steam entrenchment relative to surrounding landscape?: ____ _ m _ ft

Is crop growth stunted or yellowing at this site? ______ yes ______ no

Is soil cracked in irregularly shaped polygons at this site? ______yes ______no

Are deep tire ruts or footprints evident at this site? ______yes ______no

Is site inundated or saturated? ______yes ______ no Depth:______ m _ ft

Subsurface water observed? ______yes ______ no Depth: ______m _ ft

Does soil emit a "rotten egg" odor? ______ yes ______no

Is this soil a histosol? ______ yes ______no

Decision based on: ______soil survey ______ site determination

Thickness of organic material: ______ _ cm _ in

Depth to bedrock: ______ _ m _ft

Does soil shake underfoot? ______ yes ______ no

Plant fibers visible? ______ yes ______no

Is this a mineral soil? ______ yes ______no

Decision based on: ______soil survey ______ site determination

Are drainage structures evident? ______ yes ______ no _tiles _ditches _other

Decision based on: ______photos ______site investigation

Are retention structures evident? ______ yes ______no _weir _dike _other

Decision based on: ______photos ______site investigation

Layers of sand/gravel found within 1.2 m (4 ft) of soil surface? ______ yes ______ no

Depth:______ _cm _in Thickness:______ _cm _in

Iron or manganese concretions observed? ______yes ______no Size:______ _mm _in

Notes:

Level 1 Hydrogeology Assessment

Site name:______________________________ Date:______________
Location: Section (1/4, 1/4, 1/4)______________ T.______ R.______
County:______________ Local address:______________________
USGS quad:______________ NWI/IWI classification:______________
Site size: (hectares/acres)______________________________
Weather conditions and recent trends: (ppt and amounts, temp., sky conditions). Data available from the State Climatologist at the Illinois State Water Survey. ______________________________

____

Land use of site, buffer area, and surrounding area: (present uses, sizes). Note information on maps or aerial photographs of the site.

Prior history of site and buffer areas: (known uses, alterations). Note information on map or aerial photo of the site.

Relationship of site to cultural features: (parks, industry, residential areas, transportation, and wildlife corridors). Portray on a regional map.

Regional water table information and bedrock geology: Acquire from the Illinois State Geological Survey, the Illinois State Water Survey, and local resources (county engineers, health department, etc.).

Sediments (material above bedrock): (stratigraphy, thickness, structure, saturation, aquifers, aquitards). Need to know location of any water bearing strata (aquifers) and materials that limit the movement of water (aquitards).

Soils: (types, landscape positions, descriptions, deviation from mapping, hydric soil indicators). Acquire from NRCS county soil maps and Level 1 Soils Assessment form. Enlarge or reduce NRCS map to fit available site map.

Topography: (slope, relief, benchmarks). Is the site level, sloped, and what is the relief (difference between high and low elevations)?

Landscape position of the site (geomorphic setting): Where is site located in the landscape—upland, valley bottom, floodplain? Landscape diagrams in county soil publications can provide this information.

Surface water: (inputs, outputs, slope, area, size, depth, flow directions, alterations).

Ground water: (depth, potential inputs and outputs, flow directions, seeps, recharge area)

Morphology of present wetlands: (orientation, connectivity, size, shape)

Level 1 Vegetation Assessment

Site name: ____________________ Date: ____________

Location: Section (1/4, 1/4, 1/4) ____________________ T. ______ R. ______

County: ______________ Local address: ____________________

USGS quad: ______________ NWI/IWI classification: ____________________

Site size: (hectares/acres) ____________________

Weather conditions and recent trends: (ppt and amounts, temp., sky conditions). Data available from the State Climatologist at the Illinois State Water Survey. ____________________

Plant community: ______________ Veg. cover type: ______________

SPECIES	STRATUM	DOM.	WET.IND.STATUS	ABUND.

Plant community: ______________________ Veg. cover type: ______________________________

SPECIES	STRATUM	DOM.	WET.IND.STATUS	ABUND.

Level 1 Wildlife Assessment

Site name:____ Date:________________
Location: Section (1/4, 1/4, 1/4) ________________________T._______ R._______
County:____________________ Local address:________________________________
USGS quad:____________________ NWI/IWI classification:____________________
Site size: (hectares/acres)____
Weather conditions and recent trends: (ppt and amounts, temp., sky conditions). Data available from the State Climatologist at the Illinois State Water Survey. ____________________________
____

For each of the following criteria check the choice that applies to the target wetland and enter the numerical score for that choice in the "Score" column.

			Score
A. Dominant Wetland Type			
Emergent	(50)	_____	
Forested	(30)	_____	
Scrub-shrub	(20)	_____	
Open water	(10)	_____	_____
B. Number of Wetland Types Present			
>3 types	(30)	_____	
2-3 types	(20)	_____	
1 type	(10)	_____	_____

Note: For wetlands >5 acres, count wetland types that cover >20% of area; if wetland is <5 acres, count as 1 wetland type only

C. Size			
>20 acres	(50)	_____	
6-20 acres	(30)	_____	
5 acres or less	(10)	_____	_____
D. Landscape Position			
part of wetland complex	(30)	_____	
isolated wetland	(10)	_____	_____

Note: Target wetland is part of a complex if other wetlands occur within a 2-km radius

E. Surrounding Land Use			
>50% natural communities	(30)	_____	
>50% agricultural land	(20)	_____	
>50% urban/developed	(10)	_____	_____

Note: Natural communities = forest, shrubland, grassland, forbland
Agricultural land = cropland, pasture, hayfield

			Score
F. Dispersal Corridors			
present	(30)	_____	
absent	(10)	_____	_____

Note: Includes vegetated fencerows, streams, railroad rights-of-way

G. Vegetative Diversity

>5 types	(50)	_____	
2-5 types	(30)	_____	
1 type	(10)	_____	_____

Note: Count only types of vegetation that compose >10% of total vegetative cover; "types" refers to general categories such as cattails, sedges, rushes, bulrushes, broad-leaved emergents, deciduous shrubs

H. Food Abundance

320-400 pts	(50)	_____	
240-319 pts	(40)	_____	
160-239 pts	(30)	_____	
80-159 pts	(20)	_____	
0-79 pts	(10)	_____	_____

Note: Use lists of food items on page 149 to determine ratings

I. Hydroperiod

permanent standing water	(50)	_____	
standing water part of year	(20)	_____	
no standing water	(10)	_____	_____

J. % Open Water

21-50%	(50)	_____	
>50%	(20)	_____	
1-20%	(20)	_____	
none	(10)	_____	_____

K. Water/Vegetation Interspersion

high	(50)	_____	
medium	(40)	_____	
low	(20)	_____	
none	(10)	_____	_____

Note: See Figure 1 for examples of each category

L. Special Habitat Features

common	(30)	_____	
present	(20)	_____	
absent	(10)	_____	_____

Note: Includes brush piles, logs, snags, dead trees, muskrat houses

M. Wildlife Observations

			Score
T and E species nesting	(500)	_____	
T and E species present	(100)	_____	
obligate wetland species	(50)	_____	
generalists/opportunists	(10)	_____	_____

Note: See wetland species list (page 152)

Total score _____
(add scores for criteria A-M)

Wildlife Food Resources

Users can observe and identify groups of plants or animals to the best of their knowledge and put check marks beside those that are observed. For plants, at least **five** individuals (woody) or **25** individuals (herbaceous) should be observed for the group to be included. For example, oaks are an important food source because of the acorns that are produced; however, one oak sapling would not be an important food factor in a wetland. The abundance of animal groups is based on visibility, *i.e.*, groups that are readily observed are present in greater abundance. After filling in the form, add up the total points to find the food abundance score. For example, if the wetland had a total of 280 points, the food abundance score would be 40.

Plants (300 points possible)

Award 7 pts for each group present Total ______ Maximum 98 pts

___Algae
___Blackberries (*Rubus*)
___Bulrushes (*Scirpus*)
___Dogwoods (*Cornus*)
___Foxtails (*Setaria*)
___Grapes (*Vitis*)
___Oaks (*Quercus*)
___Panic grasses (*Panicum*)
___Pigweeds (*Amaranthus*)
___Pondweeds (*Potamogeton*)
___Ragweeds (*Ambrosia*)
___Sedges (*Carex*)
___Smartweeds (*Polygonum*)
___Wild cherries (*Prunus*)

Award 5 pts for each group present Total______ Maximum 65 pts

___Blueberries (*Vaccinium*)
___Coontail (*Ceratophyllum*)
___Cottonwood (*Populus*)
___Elderberry (*Sambucus*)
___Lamb's quarters (*Chenopodium*)
___Hackberries (*Celtis*)
___Maples (*Acer*)
___Poison ivy (*Toxicodendron*)
___Rice cutgrass (*Leersia*)
___Spike rushes (*Eleocharis*)
___Sumacs (*Rhus*)
___Sunflowers (*Helianthus*)
___Wild millets (*Echinochloa*)

Award 4 pts for each group present Total______ Maximum 80 pts

___Arrowheads (*Sagittaria*)
___Beeches (*Fagus*)
___Blackgum (*Nyssa*)
___Bluegrass (*Poa*)
___Buckthorns (*Rhamnus*)
___Burreeds (*Sparganium*)
___Chickweeds (*Stellaria*)
___Coralberries (*Symphoricarpos*)
___Duckweeds (*Lemna, Spirodela, Wolffia, Wolffiella*)
___Greenbriers (*Smilax*)
___Hawthorn (*Crataegus*)
___Hickories (*Carya*)
___Naiads (*Najas*)
___Nutsedges (*Cyperus*)
___Persimmon (*Diospyros*)
___Docks (*Rumex*)
___Virginia creeper (*Parthenocissus*)
___Water lilies (*Nuphar*)
___Wheat grass (*Agropyron*)
___Willows (*Salix*)

Award 3 pts for each group present Total_____ Maximum 42 pts

___Ashes (*Fraxinus*)
___Beadgrasses (*Paspalum*)
___Birch (*Betula*)
___Buttonbush (*Cephalanthus*)
___Brome grass (*Bromus*)
___Cattails (*Typha*)
___Cordgrass (*Spartina*)
___Elms (*Ulmus*)
___Horsetails (*Equisetum*)
___Plantain (*Plantago*)
___Pokeweed (*Phytolacca*)
___Purslane (*Portulaca*)
___Rose (*Rosa*)
___Sweet gum (*Liqiudambar*)

Award 1 pt for each group present   Total___   Maximum 15 pts

___Asters (*Aster*)	___Goldenrod (*Solidago*)	___Spicebush (*Lindera*)
___Begger's Ticks (*Bidens*)	___Honeysuckles (*Lonicera*)	___Vervain (*Verbena*)
___Bluestems (*Andropogon*)	___Jewelweed (*Impatiens*)	___Basswood (*Tilia*)
___Canary grass (*Phalaris*)	___Mustards (*Brassica*, etc.)	___Sweet clovers (*Melilotus*)
___Fescue (*Festuca*)	___Peppergrass (*Lepidium*)	___Sycamore (*Platanus*)

Animals (100 points possible)

Award points if present
___Mollusca (snails and mussels) 50 pts
___Arthropoda (crustaceans and insects) 5-25 pts depending on abundance
___Chordata (fish, frogs, salamanders, etc.) 5-25 pts depending on abundance

	Possible points
Plant resources	300
Animal resources	100
Total	400

Total points _____
(add points from Plant and Animal categories)

Total points	Food Abundance Score
320 - 400	50
240 - 319	40
160 - 239	30
80 - 159	20
0 - 79	10

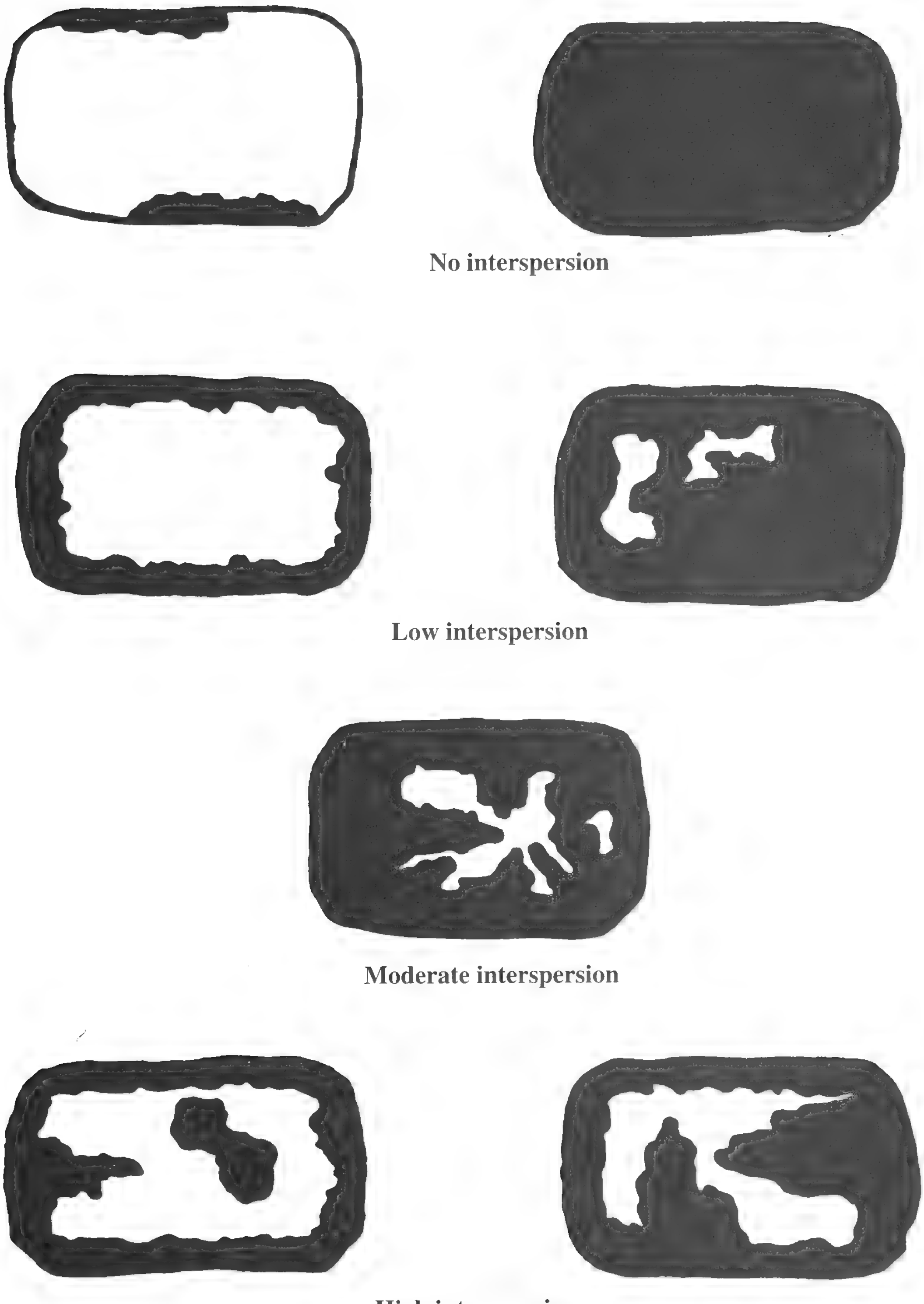

Figure 1. Example of water/vegetation interspersion (see Level 1 wildlife assessment form, part K on page 148).

List of wetland wildlife species

A. Threatened (T) and endangered (E) species

Pied-billed grebe (T)
Double-crested cormorant (T)
American bittern (E)
Least bittern (E)
Great egret (T)
Snowy egret (E)
Little blue heron (E)
Black-crowned night-heron (E)
Yellow-crowned night-heron (T)
Osprey (E)
Mississippi kite (E)
Bald eagle (E)
Northern harrier (E)
Red-shouldered hawk (E)
Yellow rail (E)
Black rail (E)
King rail (T)
Common moorhen (T)
Sandhill crane (E)
Piping plover (E)
Wilson's phalarope (E)
Common tern (E)
Forster's tern (E)
Least tern (E)
Black tern (E)
Short-eared owl (E)
Brown creeper (T)
Veery (T)
Swainson's warbler (T)
Henslow's sparrow (T)
Yellow-headed blackbird (T)
River otter (E)
Bobcat (T)
Marsh rice rat (T)
Illinois chorus frog (*Pseudacris streckeri illinoensis*) (T)
Silvery salamander (*Ambystoma platineum*) (E)
Cooter (*Pseudemys concinna*) (E)
Illinois mud turtle (*Kinosternon flavescens spooneri*) (E)
Four-toed salamander (*Hemidactylium scutatum*) (T)
Spotted turtle (*Clemmys guttata*) (E)
Broad-banded water snake (*Nerodia fasciata*) (E)
Eastern ribbon snake (*Thamnophis sauritus*) (E)
Eastern massasauga (*Sistrurus catenatus*) (E)
Green water snake (*Nerodia cyclopion*) (T)

B. Species that are obligate wetland users or are strongly associated with wetlands for some part of their life history requirements

Blue-winged teal
Virginia rail
Sora
American coot
Marsh wren
Prothonotary warbler
Swamp sparrow
Swamp rabbit
Muskrat
Beaver
Mink
Jefferson salamander (*Ambystoma jeffersonianum*)
Blue-spotted salamander (*Ambystoma laterale*)
Spotted salamander (*Ambystoma maculatum*)
Marbled salamander (*Ambystoma opacum*)
Mole salamander (*Ambystoma talpoideum*)
Smallmouth salamander (*Ambystoma texanum*)
Tiger salamander (*Ambystoma tigrinum*)
Cave salamander (*Eurycea lucifuga*)
Eastern newt (*Notophthalmus viridescens*)
Lesser siren (*Siren intermedia*)
American toad (*Bufo americanus*)
Fowler's toad (*Bufo woodhousii fowleri*)
Northern cricket frog (*Acris crepitans*)
Bird-voiced treefrog (*Hyla avivoca*)
Cope's gray treefrog (*Hyla chrysoscelis*)
Green treefrog (*Hyla cinera*)
Eastern gray treefrog (*Hyla versicolor*)
Spring peeper (*Pseudacris crucifer*)
Upland chorus frog (*Pseudacris feriarum*)
Western chorus frog (*Pseudacris triseriata*)
Eastern narrowmouth toad (*Gastrophryne carolinensis*)
Eastern spadefoot (*Scaphiopus holbrookii*)
Crawfish frog (*Rana areolata*)
Plains leopard frog (*Rana blairi*)
Bullfrog (*Rana catesbeiana*)
Green frog (*Rana clamitans*)
Pickerel frog (*Rana palustris*)
Northern leopard frog (*Rana pipiens*)
Southern leopard frog (*Rana sphenocephala*)
Wood frog (*Rana sylvatica*)
Snapping turtle (*Chelydra serpentina*)
Painted turtle (*Chrysemys picta*)
Blanding's turtle (*Emydoidea blandingii*)
Slider (*Trachemys scripta*)
Mud turtle (*Kinosternon subrubrum*)
Common musk turtle (*Sternotherus oduoratus*)
Mud snake (*Farancia abacura*)
Copperbelly water snake (*Nerodia erythrogaster*)
Diamond-backed water snake (*Nerodia rhombifer*)
Northern water snake (*Nerodia sipedon*)
Graham's crayfish snake (*Regina grahamii*)
Queen snake (*Regina septemvittata*)
Brown snake (*Storeria dekayi*)
Western ribbon snake (*Thamnophis proximus*)
Plains garter snake (*Thamnophis radix*)
Eastern garter snake (*Thamnophis sirtalis*)
Water moccasin (*Agkistrodon piscivorus*)

Appendix H: Field Guides

Geology

Handbook of Illinois Stratigraphy. H.B. Willman, E. Atherton, T.C. Buschbach, C. Collinson, J.C. Frye, M.E. Hopkins, J.A. Lineback, and J.A. Simon. Bulletin 95. Illinois State Geological Survey, Urbana, Illinois, 1975.

Hydrogeology of Wetlands. T.C. Winter and M.R. Llamas, eds. Journal of Hydrology (Special Issues) volume 141, Elsevier, 1993.

Plants

A Field Guide to the Wetlands of Illinois. Illinois Department of Conservation, Springfield, Illinois, 1988.

Aquatic Plants of Illinois. Illinois State Museum Popular Science Series Vol. VI. G.S. Winterringer and A.C. Lopinot. Department of Registration and Education, Illinois State Museum Division, and Department of Conservation, Division of Fisheries, Springfield, Illinois, 1977.

Fieldbook of Illinois Shrubs. L.R. Tehon. Illinois Natural History Survey Manual 3. Urbana, Illinois, 1942.

Forest Trees of Illinois. Sixth edition. R.H. Mohlenbrock. Illinois Department of Conservation, Springfield, Illinois. 1990.

Guide to the Flora of Illinois. R.H. Mohlenbrock. Southern Illinois University Press, Carbondale and Edwardsville, Illinois, 1986.

Prairie Plants of Illinois. J.W. Voigt and R.H. Mohlenbrock. Illinois Department of Conservation, Division of Forest Resources and Natural Heritage, Springfield, Illinois.

Tallgrass Prairie Wildflowers. D. Ladd and F. Oberle. Falcon Press Publishing Company, Inc., Helena, Montana, 1995.

The Audubon Society Field Guide to North American Trees, Eastern Region. E.L. Little. Alfred A. Knopf, Inc., New York, 1980.

Wetland Plants and Plant Communities of Minnesota and Wisconsin. S.D. Eggers and D.M. Reed. U.S. Army Corps of Engineers, St. Paul District, St. Paul, Minnesota, 1987.

Wildflowers and Weeds. B. Courtenay and J. H. Zimmerman. Prentice Hall Press, New York, 1978.

Water Quality

Pocket Sampling Guide for Operators of Small Water Systems: Phases II and V. EPA/814-B-94-001. Office of Ground Water and Drinking Water, U.S. Environmental Protection Agency, Cincinnati, Ohio, July 1994. Available through the EPA Safe Drinking Water Hotline: 1-800-426-4791.

Wildlife

A Field Guide to Animal Tracks. O.J. Murie. Second edition. Peterson Field Guide 9. Houghton Mifflin Company, Boston, 1974.

A Field Guide to the Birds of Eastern and Central North America. R.T. Peterson. Fourth edition. Peterson Field Guide 1. Houghton Mifflin Company, Boston, 1980.

A Field Guide to the Birds Songs of Eastern and Central North America. R.T. Peterson, ed. Second edition. Cornell Laboratory of Ornithology. Houghton Mifflin Company, Boston, 1983. 2 cassette tapes.

A Field Guide to the Mammals. W.H. Burt and R.P. Grossenheider. Third edition. Peterson Field Guide 5. Houghton Mifflin Company, Boston, 1976.

A Field Guide to the Nests, Eggs, and Nestlings of North American Birds. C.V. Harrison. Collins Publishers, Cleveland, Ohio, 1978.

A Field Guide to Reptiles and Amphibians of Eastern and Central North America. R. Conant and J. T. Collins. Third edition. Peterson Field Guide 12. Houghton Mifflin Company, Boston, 1991.

Birds of North America. C.S. Robbins, B. Bruun and H.S. Zim. Golden Press, New York, 1966.

Field Guide to the Birds of North America. Second edition. National Geographic Society, Washington, DC., 1987.

Guide to Bird Sounds. Cornell Laboratory of Ornithology, Ithaca, NY. 1985. 2 cassette tapes; also available on CD (for use with the National Geographic Society's *Field Guide to the Birds of North America*).

Illinois Toad and Frog Calls. Cassette tape available on loan from the Illinois Department of Natural Resources, Division of Natural Heritage, 524 S. Second St., Springfield, Illinois 62701-1787.

Talking Toads and Frogs. Cassette tape and poster. Available from the Missouri Department of Conservation, P.O. Box 180, Jefferson City, Missouri 65101.

Voices of the Night: the Calls of Frogs and Toads of Eastern North America. Cornell University, Ithaca, NY. Third edition, 1982. 1 cassette tape.

Appendix I: Quantitative Vegetation Sampling

Vegetation sampling is most commonly conducted during the assessment and monitoring phases of a planned wetland project and is described in Chapter 2, "Site Assessment" and Chapter 5, "Monitoring Restored and Created Wetlands." Quantitative sampling is presented as an option for a detailed level of assessment or monitoring. This appendix includes suggested quantitative sampling methods for determining dominance, frequency, density, and survivorship in herbaceous, shrub, sapling, tree, and woody vine strata.

A. Plant communities

In a typical planned wetland project, vegetation monitoring can be conducted in a variety of plant communities, including both wetlands and nonwetlands. Natural, restored, and created wetlands include emergent wetlands, shrub-scrub wetlands, forested wetlands, and open water shallow ponds with a ring of vegetation. Natural, restored, and created nonwetlands include native grasslands (prairies), shrublands, and upland forests. Nonwetland communities are commonly part of restored or created wetland projects as buffer areas adjacent to the wetlands.

A project site is divided into separate sampling areas based on plant community characteristics. Areas grouped for sampling are relatively homogeneous throughout the unit in regard to certain structural, quality, or community characteristics. Therefore, an upland forest is sampled separately from an adjoining floodplain forest. These forests may be further subdivided for sampling purposes if, for example, very distinct differences in age of stand, quality, or species composition exist. Jurisdictional or regulatory status may also distinguish sections of a similar vegetation cover type. If a floodplain forest consists of both jurisdictional and nonjurisdictional wetland units, then these units can be sampled separately.

Sampling can have a negative impact on the plant community, especially if the soils are unstable. Unstable soils are generally found in wetland communities such as seeps, fens, some marshes, and recently created wetlands. Potential negative impacts should be taken into account when determining the frequency of sampling in these communities and the first sampling date in created communities. The early stages of created wetlands may be especially susceptible to damage and a sampling program that irreversibly damages soils or vegetation should not be conducted. Project goals and monitoring plans should reflect this concern for the development of the restored community.

B. Experimental design

The experimental design for vegetation sampling is tied directly to the goals and objectives of each project. In a regulatory setting, the sampling regime may conform to requirements from the U.S. Army Corps of Engineers (USACE) (USACE 1993) or a state agency such as the Illinois Department of Natural Resources (IDNR) or the Illinois Department of Transportation (IDOT). In a nonregulatory context, the sampling regime may arise from a desire to monitor or document plant community development.

The data collected using the methods described in this appendix can be used to calculate and determine dominance (cover or basal area), frequency, density, and species survivorship.

- **Cover** is the proportion of the ground covered by the vertical projection of the foliage of a species and can be used to measure dominance of herbaceous or woody plants.
- **Basal area** is used to determine dominance of trees and is the vertical projection of the stem on the ground, expressed as a fraction of the sampled area.
- **Frequency** is the percentage of plots or sample points at which a species occurs.
- **Density**, a measure of abundance, is the number of individuals of a species per unit area.
- **Survivorship** is the number of living individuals, usually expressed as a percentage of the number planted or present before initiating new conditions or treatment.

Vegetation sampling is conducted for several purposes. Some examples are:

- To determine the plant community characteristics of the existing wetland
- To determine if the restored or created wetland meets the revegetation standards outlined by the USACE (USACE 1993a)
- To document the natural/restored/created/managed plant community change over time
- To document plant community boundary changes over time
- To determine how plant community changes affect or relate to changes in other nonplant components (soils, bird populations, water level, water quality, etc.)

- To determine the survivorship of plantings arranged in nonrandom patterns, *i.e.*, rows, clumps, or exclosures

Each planned wetland site may call for a different sampling strategy, depending on site characteristics and the nature of information sought. The sampling methods described in the remainder of this appendix are suggestions appropriate for commonly encountered situations. Many other suitable methods exist, and the reader is encouraged to develop a sampling plan that fits project needs. At times a combination of methods may be best. When creating a sampling program, always aim to sample a randomly-selected representative amount of vegetation to reduce observer bias as much as possible. As a project and its associated plant communities mature, sampling methods may need to be adjusted to reflect changes in species composition, structure, or distribution. For instance, in the early stages of a restored wetland, no shrub stratum may exist; if a shrub community develops at the site, a sampling plan for the new stratum must be developed. Other physical aspects, such as open water or bare ground surface area (as a subset of total surface area of the site), will also differ among sites and influence sampling design. For additional advice regarding sampling, consult local experts (see Appendix B, "Natural Resources Agencies").

C. Plant community strata

Each stratum (herbaceous, shrubs and saplings, trees, and woody vines) of the plant community is sampled separately. Immature woody vegetation is assessed with the stratum it best matches in size and habit at the sampling time. For example, poison ivy can be sampled as an herb, a shrub, or a woody vine. Herbaceous, shrub, sapling, tree, and woody vine strata are defined as:

- Herb — Graminoids; forbs; ferns; fern allies; herbaceous vines; tree, shrub, and woody vine seedlings < 1 m (< 3.2 ft) tall
- Shrub — Multi-stemmed, brushy shrubs and small trees and saplings >1 m (3.2 ft) and < 6.1 m (20 ft) tall, dbh < 2.5 cm (1 in)
- Sapling — Young trees ≥ 6.1 m (20 ft) tall, dbh < 12.7 cm (5 in) and ≥ 2.5 cm (1 in)
- Tree — ≥ 6 m (20 ft) tall, dbh ≥ 13 cm (5 in)
- Woody vine — Woody plant with a trailing or climbing stem, not self-supporting

D. Sampling randomly arranged (natural) plant communities

Three sampling methods are presented for sampling natural herbaceous, shrub, or forested communities: **quadrat**, **belt transect**, and **point-quarter**. A baseline and transects along which the sampling is conducted must be established for each of these methods.

- Quadrat (plot) sampling is often used for herbaceous communities or for the herbaceous component of shrub or forest communities.
- Belt transects are suitable for quantifying shrubs and scattered trees in shrub-scrub wetlands, shrublands, and forests.
- The point-quarter method is used for sampling trees in forested communities.

These methods can be used together within a single community if several strata are present. Detailed information on quantitative vegetation sampling methods may be found in Daubenmire (1959), Braun-Blanquet (1965), Mueller-Dombois and Ellenberg (1974), Smith (1980), Pielou (1986), and Horner and Raedeke (1989). See Figure 1, page 159 for diagrams of the above methods.

Establishing the sampling program in the field and data collection

1. Lay out the baseline and transects (See Figure 1, page 159)

   - Determine the approximate area of the plant community to be sampled.
   - Lay out a baseline parallel to the long axis of the area, either along one side or within the area, or perpendicular to any obvious uni-directional gradient (Magee *et al.* 1993). Record the location of the starting point of the baseline and the compass direction it follows. The starting point should be described at least in part using a permanent feature, such as the fence post in the following description, *e.g.*, 50 m (164 ft) northeast (42°) of the 3rd fence post (a permanent feature) along the north edge of the wetland.
   - Determine the percentage of the total area that should be sampled to provide a reliable measure of the overall site. This can be done by constructing a species-area curve that plots the total number of species that occur in a successively larger sampling area (Mueller-Dombois and Ellenberg 1974). Another method is to calculate a certain

representative percentage of the total area, usually from 5 to 8%, and determine the number and size of plots or transects necessary. Transects lie perpendicular to the baseline.

2. Quadrat (plot) method
The quadrat method typically is used to sample herbaceous vegetation. Small shrubs, tree seedlings, and woody vines that are <1 m (3.3 ft) tall are included in this stratum. Herbaceous vegetation should be sampled first because it can be trampled during the sampling of other strata. Quadrat sampling will produce data that can be analyzed to yield dominance (cover), frequency, and density information.
Quadrat sampling consists of measuring certain characteristics of plant composition within a series of quadrats (plots). Plots are generally 0.25 m^2 (2.7 ft^2) or 1.0 m^2 (10.8 ft^2). To determine cover and frequency, all herbaceous species found in each plot are listed and cover classes are recorded (Table 1). To determine density, the number of individual plants or stems of each species within the plot is counted.

Table 1. Vegetation cover classes, adapted from Daubenmire (1959).

Cover class	Range of cover (%)	Midpoint of range
1	0- 1	0.5
2	1- 5	2.5
3	5-25	15.0
4	25-50	37.5
5	50-75	62.5
6	75-95	85.0
7	95-100	97.5

3. Belt transect method
Belt transects are typically used to sample woody vegetation, such as shrubs, saplings, trees, and woody vines. Belt transect sampling will produce data that can be analyzed to yield dominance (cover), frequency, and density information.
Belt transect sampling consists of measuring characteristics of plant composition within a belt located along a transect. Belts are commonly 2 m (6.6 ft) wide and may be continuous or in equal-sized segments at specified intervals along the transect. To determine cover and frequency, all shrub, sapling, tree, and woody vine species that have foliage within the transect are listed and cover classes are recorded.
To determine density, the number or individual plants or stems of each species within the belt is recorded.

4. Point-quarter method
The point-quarter method (Cottam and Curtis 1956) is typically used to sample trees and woody vines. Point-quarter sampling will produce data that can be analyzed to yield dominance (basal area), frequency, and density information.
To conduct point-quarter sampling, points are established along a transect with the interval spacing dependent on the density of the forest stand (*i.e.*, the denser the forest, the closer the points should be). Each point is considered the center of four quarters (quadrants). In each quadrant, the distance from the center point, species, and diameter (dbh) of the tree nearest to the center point are recorded. Any woody vines growing on the recorded trees should be noted.

E. Sampling nonrandomly arranged or aggregated (planted) plant communities
Vegetation in restored or created wetlands may be planted in clumps, rows, exclosures, around the basin perimeter, or in other nonrandom arrangements. Sampling recently planted vegetation with methods that assume random arrangements of plants will not provide accurate or adequate information about the plant community. An exception to this involves herbaceous species mechanically seeded in rows, typically seeded at a rate and spacing that make conventional methods appropriate. In the case of row, clump, or planting exclosure arrangements, thorough and accurate landscape plans, drawings, and as-built plans are necessary so that meaningful comparisons can be made during the post-construction monitoring period. The exact location of individual plants may not be known, but a total number of individual plants of each species and the planting configuration should be available.

The initial stages of nonrandom plant communities are often sampled to determine survivorship of plantings. Usually a subset of plants will be selected to make the sampling effort efficient. In all cases, this subset should be selected randomly to remove bias toward certain locations or visual clues. These totals can be compared to information provided on the as-built planting plans to indicate survivorship of the planting. Replanting can be recommended if levels of mortality are unacceptable. Replanting details should be carefully recorded and integrated with as-built plans for future comparisons.

As planted communities mature, the nonrandom nature of the planting arrangement usually diminishes. The length of time necessary for this process to occur varies with the type of community (*e.g.*, herbaceous or woody). As plants grow, seed themselves, or spread outward from their original locations into

a more random arrangement, the original plantings become less obvious. As long as the regular or aggregated patterns of the planting regime are dominant, sampling must be carried out according to those features.

Conventional sampling methods described in Section D of this appendix can be used along with nonrandom methods in two instances. They can be used to evaluate the development of a randomly-arranged plant community that surrounds the plantings. They can also be used for the whole site once the nonrandom nature of the plantings has been outgrown. Wetland managers will need to choose the most appropriate methods for each community during the duration of the sampling period.

The most common nonrandom arrangements are rows, clumps, exclosures, and peripheral vegetation. Suggestions concerning sampling these communities are presented below.

1. Rows: herbaceous and woody plants can be planted in rows.

   - To sample for survivorship: count individual plants if the site is small; if the area is large, representative areas can be sampled. When species are randomly dispersed within and among the rows, a randomly selected subset of the rows or segment of each row can be sampled. If the species are arranged in zones according to gradient (*e.g.*, topographic or moisture) or some other nonrandom feature, then a representative area within each zone should be sampled.
     In all cases, sampling includes compiling a list of all planted species in each row, noting the condition (*e.g.*, dead or alive) of each individual plant encountered. These totals can be compared to the as-built planting plans to provide a measure of the success or survivorship of the planting.

2. Clumps: herbaceous and woody vegetation may be planted in clumps, or groups, of plants at a wetland site.

   - To sample for survivorship: in a small area, individual plants can be counted; in larger areas, a subset should be assessed. If several different species are randomly mixed within the clump, a randomly selected subset could be sampled. If the species are distributed in zones according to a gradient or some other feature that is not random, then a representative area within each zone should be sampled. All individual plants within each sampling unit should be counted, noting species and condition. These totals are then compared with information provided on the as-built planting plans to evaluate survivorship.

3. Planting exclosures: herbaceous vegetation is sometimes planted within planting exclosures (boxes) to protect young plants from herbivory. These boxes may be arranged in groupings within the restored or created wetland.

   - To sample for survivorship: individual plants within the boxes are counted, and the survivor totals compared with the original planting information detailed in the as-built plans. All plants within all boxes can be counted if few are present, or all plants within a subset of the boxes can be counted. First the percentage of boxes to sample should be determined, then a subset of the boxes should be randomly selected.
     Plants within the boxes are assessed, either by counting individual plants or estimating cover of individual species or overall cover. The design of the exclosure itself (*e.g.*, mesh covering) or the growth habit of the particular species (*e.g.*, grasses may form many shoots), may make the determination of individual plants difficult.

4. Peripheral vegetation: often, created wetlands consist of open water surrounded by a narrow zone of vegetation. The width of the zone generally varies with the steepness of the slope, with steeper slopes resulting in narrower bands of vegetation. The location of the zone along the slope may vary from year to year depending on the precipitation amounts and the resulting water depth/height along the shoreline. These vegetation zones pose their own set of sampling restraints. They can be sampled with quadrats along a transect within the emergent zone or with quadrats along a transect across the basin, depending on the configuration of the emergent zone. Magee *et al.* (1993) offer many useful suggestions for setting up transect and plots within a wetland basin.

   - Transects within the emergent zone: this method can be used if vegetation is mostly limited to a narrow emergent zone and will provide information about the composition and plant community development within the zone. If the zone is so narrow that only one plot can fit across it, the transect can be laid parallel to the center of the zone and encircle the basin. Quadrats (plots) can then be laid along the transect length at fixed or

random intervals. If all or part of the zone is wider, a baseline can be laid out along the median line of the zone, with intersecting perpendicular transects. Quadrats can be laid along the transects, with each transect's total number of plots varying with the width of the zone at that location. The location of the emergent zone may vary annually with varying amounts of precipitation. If changes in the zone's location are important to document, transect starting points could be measured annually from a fixed location on or outside of the baseline, *i.e*, a fence line, property boundary, or another baseline. See Figure 2, page 159.

- Transects across the basin: transects laid out across the basin can provide useful information about the composition and development of the plant community within the entire basin. Setting up the baseline and transects is the same as described in Section D of this appendix. If the vegetation is not evenly distributed throughout the basin, the number of transects should be adjusted so that a representative sample of vegetation is obtained.

F. Data analysis

The approach to data analysis depends upon the type of information sought and the type of data collected. Various kinds of characterization techniques are available, including importance values, characterization or performance curves, and scatter or box plots. Multivariate methods such as cluster analysis or multiple regression can show relationships between two variables. T-tests, analysis of variance, or other multivariate methods compare data between sites or years. Basic ecology and ecological statistics texts can provide guidance concerning which analyses and tests are appropriate and detailed descriptions on how to conduct each analysis. Frequently used texts include Kershaw (1973), Mueller-Dombois and Ellenberg (1974), Grieg-Smith (1983), Pielou (1977), Smith (1980), and Ludwig and Reynolds (1988).

Literature Cited

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Magee, T.K., S.E. Gwin, R.G. Gibson, C.C. Holland, J.E. Honea, P.W. Shaffer, J.C. Sifneos, and M.E. Kentula. 1993. Research plan and methods manual for the Oregon wetlands study. Document production by K. Miller. EPA/600/R-93/072. U.S. Environmental Protection Agency, Environmental Research Laboratory, Corvallis, Oregon.

Mueller-Dombois, D, and H. Ellenberg. 1974. Aims and methods of vegetation ecology. John Wiley and Sons, New York.

Pielou, E.C. 1977. Mathematical ecology. John Wiley and Sons, New York.

_______. 1986. Assessing the diversity and composition of restored vegetation. Canadian Journal of Botany 64:1344-1348.

Smith, R.L. 1980. Ecology and field biology. Harper and Row. New York.

U.S. Army Corps of Engineers, Chicago District. 1993. Guidelines for developing mitigation proposals. Chicago, Illinois. September.

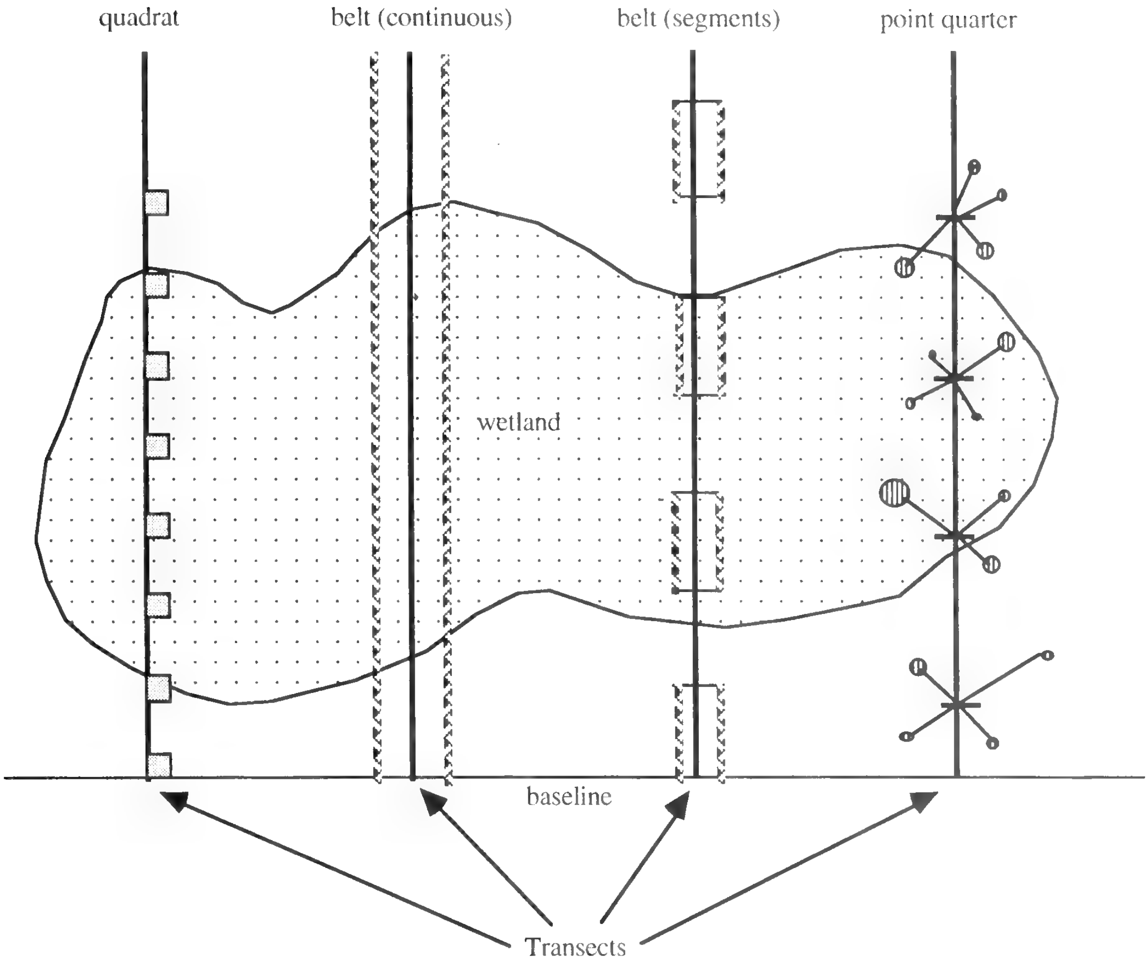
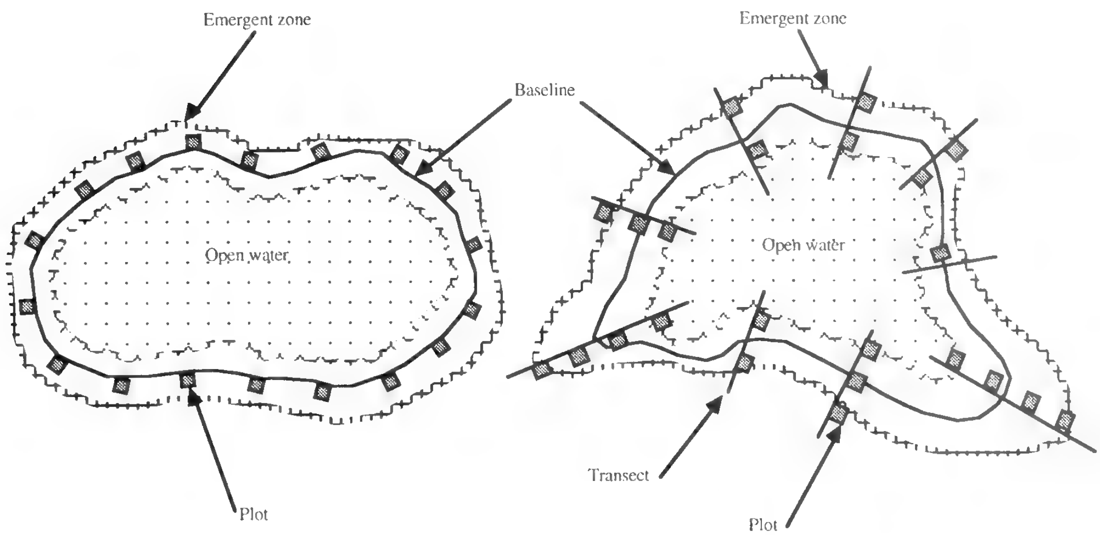


Figure 1. Baseline and transect layout for quadrat, belt, and point quarter sampling.



The emergent zone is narrow and supports only one plot; plots are laid along the baseline.

The emergent zone is wide and supports more than one plot; plots are laid along a transect that is perpendicular to the baseline.

Figure 2. Layout of baseline, transects, and plots within a peripheral emergent zone.

Appendix J: Illinois Natural Areas Inventory Natural Quality Grading

The grading system outlined here is described fully in the Illinois Natural Areas Inventory Technical Report for all natural communities (White 1978). In order to become proficient in applying this method, the wetland designer or manager should consult with professionals experienced in this method and seek out within the same region Grade A and B natural plant communities as defined and described in the Natural Areas documentation and become familiar with their flora and natural characteristics. Refer to Appendix C, "Natural Resources Agencies," and Appendix Q, "Illinois Wetland Nature Preserves."

INAI Grade Descriptions

Grade A: relatively stable or undisturbed communities. Some examples are 1) old growth, ungrazed floodplain forest; 2) wet prairie with undisturbed soil and a natural plant species composition; 3) a wetland with unpolluted water, unaltered water level, and natural vegetation.

Grade B: late successional or lightly disturbed communities. Some examples are 1) old growth forest that was selectively logged 5 years ago; 2) old second growth forest that had moderate grazing, but now is in the late recovery stage; 3) prairie with somewhat weedy composition because the soil was graded 15 years ago; and 4) wetland in which original water levels have been altered, which changed species composition locally, but did not destroy the structure and natural diversity of the community.

Grade C: mid-successional or moderately to heavily disturbed communities. This grade includes a broad range of degrees of disturbance. Some examples are: 1) heavily grazed old growth forest; 2) young to mature second growth forest; 3) prairie that has been grazed so long that many native species have been replaced by weeds; and 4) wetland with artificial water level that has changed the structure and composition of the vegetation.

Grade D: early successional or severely disturbed communities. Some examples are: 1) recently clearcut forest; 2) mature second growth severely grazed forest; 3) railroad remnant prairie with graded soil, dominated by weeds, with many native species missing; and 4) wetlands that have been artificially flooded or drained, greatly changing the vegetation.

Grade E: very early successional or very severely disturbed communities. Some examples are: 1) newly cleared land; 2) cropland; 3) improved pastureland; and 4) railroad embankment.

Grazing pressure: grazing is a common disturbance to natural communities in Illinois. Grazing pressure can be separated into six classes, defined below.

None: little or no evidence of grazing is present.

Light: evidence of grazing is obvious. A browse line is developing and natural understory reproduction has stopped. A small gap in the age of the understory is present and the concentration of thorny species is increasing.

Moderate: evidence of grazing is obvious. A definite gap exists in the natural understory and thorny species are well established. Grazing trails are well established.

Heavy: understory has been replaced by thorny shrubs. Gaps are beginning to develop in the overstory.

Severe: large gaps have developed in the overstory and thorny species are entering the canopy. The edges of woods and fencerows (particularly in fence corners) may be without trees or shrubs, due to continual, prolonged trampling.

Very severe: understory has been eliminated or is dying. Overstory trees are being killed. Soil is bare and eroding.

Estimating age of forests: forest communities typically are divided into five different age classes as described below. The diameter at breast height is often used as an indicator of tree age; however this measure is highly variable with species and site conditions. The most accurate measure of tree age is with ring counts using an increment borer (see Appendix C, "Resource Materials and Sources").

CLASSIFICATION	AGE OF OVERSTORY TREES
Old growth	Very old (120+ years)
Old second growth	Old (90 to 120 years)
Mature second growth	Mature (40 to 90 years)
Young second growth	Young or submature (20 to 40 years)
Regrowth	Very young (10 to 20 years)

Literature Cited

White, J. 1978. Survey methods and results. Illinois Natural Areas Inventory, Urbana. Technical Report Volume 1. November.

Appendix K: Floristic Quality Assessment

The Floristic Quality Assessment (FQA) (Swink and Wilhelm 1994; Taft *et al.* 1996) is an optional procedure that can be applied to both the assessment and monitoring phases of a planned wetland project. FQA often is used as an aid to identify high-quality natural areas among sites and can be used in assessment and monitoring of existing wetlands, planned wetlands, and potential planned wetland sites. Note that in this context, natural areas are those where the plant communities reflect perceived native, presettlement conditions, and may or may not be statewide significant natural areas according to Illinois Natural Areas Inventory standards. When utilized for monitoring, the FQA may be used to establish the baseline floristic quality of a site and observe the effects of management practices. After the wetland plant community has become established, quantitative data should be combined with the FQI in order to track important changes in abundance patterns (refer to Appendix I, "Quantitative Vegetation Sampling").

Each taxon in the Ilinois flora has been assigned a coefficient of conservatism (C) (Taft *et al.* 1996). Individual conservatism coefficients reflect each species' affinity for a natural area, *i.e.*, the coefficients are ranks of species behavior and represent the committee's (Taft *et al.*) confidence level for a taxon's correspondence to anthropogenic disturbances. Coefficient values range from 0 to 10, with all adventive species given a coefficient of 0. Plant species assigned 0 have low affinities for natural areas, whereas those assigned 10 have very high affinities. Note that C values differ between Swink and Wilhelm (1994) and Taft *et al.* (1996). Values for the former are specific to the Chicago region while those for the latter are applicable statewide. Statewide values are addressed in the following discussion and are used for tasks described in Chapters 2 and 5.

When a complete species list is assembled for a wetland site, the overall average conservatism coefficient ($\overline{C}$) and a site floristic quality index (FQI) can be calculated. Because in an evaluation it may be useful to examine the $\overline{C}$ values without including adventives, both the $\overline{C}$ and the FQI can be calculated with and without adventives. These values provide measures of site floristic quality.

Several caveats are associated with the use of this assessment method. The FQA addresses only floristic integrity and therefore must not be considered a complete biological assessment. Furthermore, it should be applied only during the growing season, because a site will certainly be given a lower rating if assessment is made during a season when many species are unidentifiable or dormant. Also, the site index and mean conservatism coefficient reflect the skill of the botanist conducting the survey. Uncommon species may be overlooked by someone with less training or experience. Finally, because the index and $\overline{C}$ are based on presence and absence only, the method is more informative when combined with quantitative data.

The steps to conduct the FQA are as follows:

- assemble a comprehensive plant species list for the study site. Effort should be made to include all species (native and nonnative) present.
- refer to the list of FQA values (Taft *et al.* 1996) to find the conservatism coefficient ($\overline{C}$) for each species.
- calculate and report the average conservatism coefficient ($\overline{C}$) for each site. Perform calculations using $\overline{C}$ values for all species, including adventives; then using $\overline{C}$ values for native species only.
- calculate and report the floristic quality index (FQI) for each site using the formula FQI = $C\sqrt{N}$, where N = the number of species. Perform calculations representing all species, including adventives; then for native species only.

FQI values generally range from 5 to greater than 70. FQI values less than 5 indicate that the area is extremely weedy or in an early successional stage (Swink and Wilhelm 1994). FQI values between 20 and 35 ($\overline{C} \geq 3.0$) indicate that the area has evidence of native character and can be considered a botanical asset. FQI values between 35 and 50 ($\overline{C} \geq 3.5$) indicate that the area has significant native character. FQI values greater than 50 indicate that the area is of paramount importance and now is extremely uncommon on the landscape. Corresponding values of $\overline{C}$ and FQI with and without adventive species will tend to be more similar in less disturbed sites, while differing more widely in degraded sites.

In a monitoring context, Swink and Wilhelm (1994) report that FQI and $\overline{C}$ values usually rise steadily after the planned wetland project is completed, but then level off after 4 to 5 years. Rarely have FQI values greater than 35 or $\overline{C}$ values greater that 3.7 been recorded in restored or created wetlands. These authors attribute this at least partially to the fact that most planned wetland sites are fed by surface water, whereas most pre-settlement wetlands (at least in the Chicago area) were fed by ground water and surface water. This reflects the current inability to mimic natural hydrologic conditions required for many species-rich natural wetlands.

Literature Cited

Swink, F., and G. Wilhelm. 1994. Plants of the Chicago region. Indiana Academy of Science, Indianapolis.

Taft, J., G. Wilhelm, D. Ladd, and L. Masters. 1996. Floristic quality assessment for Illinois. Erigenia (in prep.).

Appendix L: Rare Species Assessment and Monitoring

Rare species, including species listed as threatened or endangered in the state of Illinois and at the federal level, are by their nature difficult to assess by conventional quantitative sampling methods. Conventional methods would be apt to miss the population entirely; therefore, methods that directly target the species are used. The amount of effort spent sampling a rare plant population depends on project goals and objectives. If the assessment is used to determine the presence of rare species at an existing wetland site, a thorough meander search in the appropriate season would be adequate. If the project goal is to maintain an intact population at a site after the planned (most likely restored) wetland is established, and continued monitoring is planned, the assessment will be used as baseline data. The sampling strategy is tailored to the proposed monitoring program to allow for meaningful comparisons. In the monitoring phase, if the project goal is to maintain an intact population after a restored wetland is established, then a simple annual census may be adequate. If the project goal is to determine the exact change in population size, vigor, or reproductive stage throughout the monitoring phase, more specific methods of describing the population are needed. Permanent plots can be installed at the beginning of the monitoring period to facilitate long-term sampling of a plant population. If detailed sampling is conducted, care should be taken to replicate the sampling effort and season in subsequent years. Refer to Goldsmith (1991) for further discussion of rare plant monitoring.

The following information is helpful when describing the location and characteristics of a plant population. First, the project site, county in which it is located, date of survey, and species sampled are important. Location of the population can be described by a community numbering system; a survey station number; the distance from a permanent landmark, such as the center line of a road, a building, a fence post, or natural feature; and the legal location, including township, range, section number, and quarter section(s). Population information can include population size, density, vigor, and reproductive stage. The description of the natural community in which the population is located includes a community cover type, the soil type, the slope or aspect, the community dominants, and associated species. A photograph or voucher specimen is taken to document the occurrence. If the population is very small (less than 20 individuals) or if few locations for the species are known within the state, few, if any, plants should be collected. Plant species population characteristics can range from discrete individuals to colonial populations. Discrete individuals can be counted and mapped onto an aerial photograph, plan sheet, or graph paper for the initial inventory and subsequent monitoring. Individual plants can be flagged in the field to facilitate locating them in the future. Colonial plants cannot be mapped as individuals; rather the boundaries of the colony are mapped and the outer boundaries of the area flagged. Because individual plants in a colony cannot be mapped, stems per unit area (*e.g.*, hectare, acre, 10 m^2, 10 ft^2, 0.25 m^2) can be counted and recorded. In both cases, if the population is large, a grid of evenly sized squares can be superimposed upon the area, and plants or stems can be counted within each grid. If the area is very large with many individuals, a subset of grid squares may be selected randomly and sampled. The grid size and location should be recorded on an aerial photograph, plan sheet, or graph paper, and the sampled blocks recorded for future reference.

A convenient tool for mapping the location and extent of individual plants or a plant population, and for monitoring them over time is illustrated in Figure 1, page 163. This azimuth and range location plotter can be built by attaching a 25 cm (10 inch) protractor to the center of a piece of 1 cm (3/8 inch) thick plywood measuring approximately 30 x 30 cm (1 ft^2). Additional refinements include a compass attached to one corner of the plywood, a center screw or nail for temporary attachment of the hooked end of a measuring tape, and two bottom pins (bolts) for setting into aluminum, steel, or PVC pipes set into the ground marking permanent plots (Schwegman 1986). This tool is similar to a Redy-mapper available in some forestry supply catalogs (see Appendix C, "Resource Materials and Sources"). The distance and angle from the permanent plot can then be recorded and mapped onto aerial photographs or graph paper. Plants can be labeled individually if certain characteristics (flowering frequency, reproductive success, growth) are measured. Colonies of plants can be mapped similarly, with distances to the outer edges of the colony recorded and mapped.

If rare species are located or introduced into planned wetlands, the occurrence or introduction should be reported to the Endangered Species Protection Board (Appendix B, "Natural Resources Agencies").

Literature Cited

Goldsmith, B. 1991. Monitoring for conservation and ecology. Chapman and Hall, London.

Schwegman, J. 1986. Two types of plots for monitoring individual herbaceous plants over time. Natural Areas Journal 6(1):64-66.

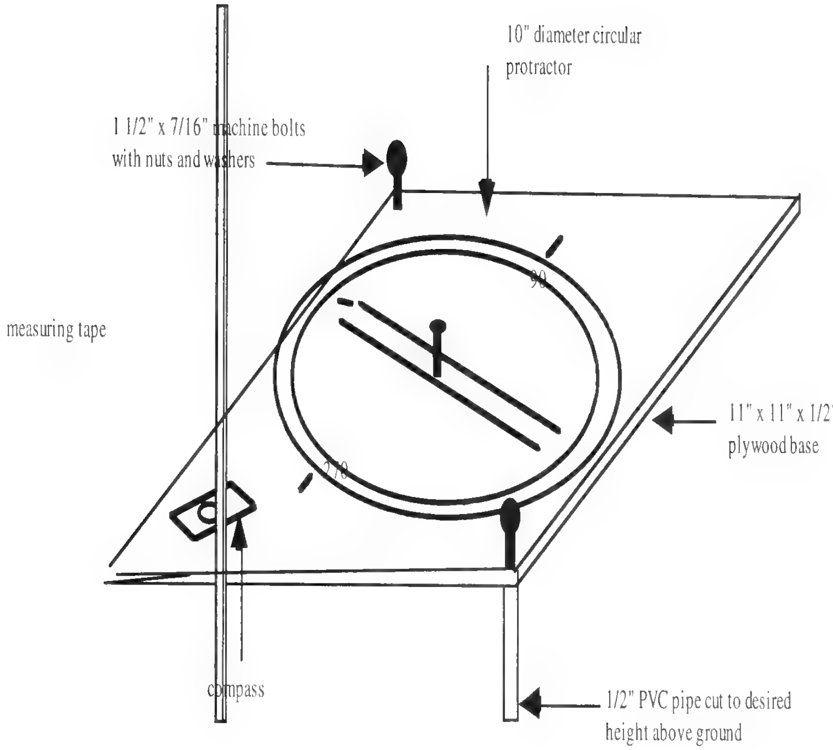


Figure 1. Azimuth and range location plotter.

Appendix M: Exotic Species Assessment and Monitoring

Exotic species are similar to rare species in that they may grow and spread in patchy populations. Therefore methods and guidelines for assessing exotic species are similar to those used to assess rare species. As described in the previous appendix on rare species assessment and monitoring, permanent plots, the use of a grid superimposed over the population, and the use of an azimuth and range location plotter (Appendix L, Figure 1) or Redy-mapper to map the location and size of a population can be adapted to assessing exotic species.

Describing the location and characteristics of an exotic species population is also very similar to describing these attributes of a rare species. The project site name, the county in which it is located, date of survey, and species sampled are basic pieces of information. Location of the population can be described by a community numbering system, a survey station number, the distance from a permanent marker, and the legal location. Population size, density, vigor, and reproductive stage are important features to record.

Another method for evaluating the impact of an exotic species is an "exotic plant species ranking system" developed by staff at the Indiana Dunes National Lakeshore, and adapted by the Minnesota Interagency Exotic Species Task Force (1991). The ranking process produces a score for an individual population and is based on the impact levels, the threat of the exotic species population, the innate reproductive and ecological characteristics of the individual species, and the feasibility of control.

Literature Cited

Minnesota Intergency Exotic Species Task Force. 1991. Report and recommendations. Submitted to the Natural Resources Committees of the Minnesota House and Senate.

Appendix N: Commercially Available Illinois Native Plant Species

The species listed in this table are native to Illinois and are not listed as state threatened or endangered. Other species are offered by these nurseries, but only those wetland plants (rated as FAC+, FACW, or OBL) offered by two or more suppliers, or prairie species offered by four or more suppliers are listed. Common names of plant species are listed in Appendix O. Supplier information is provided following this table.

	Suppliers																								
Wetland Forb Species	Bf	Bp	Cr	Cw	Gn	Ie	Ip	Jj	Jn	Kw	Lh	Lv	Ma	Me	Mw	Ng	Pf	Pm	Pn	Pp	Pr	Ps	Ss	Tc	Wn
Acorus calamus			•	•		•	•	•		•	•		•	•		•		•			•		•	•	•
Alisma plantago-aquatica		•		•	•	•	•	•	•	•	•		•	•		•		•			•		•	•	•
Amsonia tabernaemontana		•							•							•							•		
Anemone canadensis		•		•	•	•	•					•		•		•	•	•	•		•	•		•	
Angelica atropurpurea				•	•	•					•	•	•	•		•		•	•		•			•	
Arisaema triphyllum					•	•	•	•				•	•			•		•	•				•		
Asclepias incarnata	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•
Aster lateriflorus						•												•				•	•		
Aster novae-angliae	•	•	•	•	•	•	•		•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	
Aster praealtus		•														•									
Aster puniceus				•	•	•	•				•		•	•		•		•			•			•	
Aster simplex				•	•	•					•		•	•				•			•			•	
Aster umbellatus					•	•										•		•				•		•	
Bidens cernua					•	•			•		•							•						•	
Bidens coronata				•		•					•							•			•				
Bidens frondosa					•						•										•			•	
Boltonia asteroides		•			•	•					•					•		•					•	•	
Cacalia suaveolens					•											•		•	•					•	
Caltha palustris			•	•		•	•	•				•	•	•		•		•	•		•		•	•	
Cassia hebecarpa	•															•	•	•	•		•			•	
Cassia marilandica		•			•						•							•					•		
Castilleja coccinea											•				•	•	•					•			
Chelone glabra	•			•	•	•	•		•				•	•		•	•	•	•			•	•	•	
Cicuta maculata						•										•		•						•	
Cirsium muticum				•										•		•						•		•	

	Suppliers																								
Wetland forb species, cont.	Bf	Bp	Cr	Cw	Gn	Ie	Ip	Jj	Jn	Kw	Lh	Lv	Ma	Me	Mw	Ng	Pf	Pm	Pn	Pp	Pr	Ps	Ss	Tc	Wn
Decodon verticillatus						•									•			•					•		
Eupatorium coelestinum		•							•									•					•		
Eupatorium maculatum			•	•	•	•	•			•	•	•	•	•		•	•	•	•	•	•			•	
Eupatorium perfoliatum			•	•	•	•	•		•				•	•		•	•	•	•		•	•		•	
Eupatorium purpureum	•				•	•					•				•	•		•			•			•	
Gentiana andrewsii	•			•	•	•	•	•			•	•	•	•		•	•	•	•		•	•	•	•	
Gentianopsis crinita	•										•						•	•				•		•	
Gerardia (Agalinus) tenuifolia		•					•											•	•			•	•	•	
Helenium autumnale	•	•	•	•	•	•	•		•		•	•	•	•		•	•	•			•		•	•	
Helianthus grosseserratus		•				•	•										•	•	•		•	•		•	
Heracleum lanatum					•	•					•							•	•		•			•	
Hibiscus laevis (militaris)		•			•	•					•							•							
Hibiscus lasiocarpus		•													•										
Hydrophyllum virginianum												•						•			•				
Hypericum pyrimidatum	•	•		•	•	•	•							•		•		•	•			•		•	
Impatiens capensis (biflora)				•		•					•			•				•			•				
Iris (virginica) shrevei	•	•	•		•	•	•		•		•	•		•	•	•	•	•	•		•	•	•	•	
Lilium michiganense		•				•	•	•				•		•		•	•	•	•		•	•		•	
Lobelia cardinalis	•	•	•	•	•	•	•	•	•		•	•	•		•	•		•	•	•	•		•	•	•
Lobelia siphilitica	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•
Ludwigia alternifolia		•			•	•			•							•		•							
Lycopus americanus		•							•									•						•	
Lysimachia quadriflora						•										•		•	•			•			
Lythrum alatum					•	•										•		•				•		•	
Mertensia virginica								•	•			•				•		•					•		
Mimulus ringens					•	•			•				•	•		•		•						•	
Napaea dioica		•		•	•						•			•				•	•		•			•	
Oxypolis rigidior					•											•	•					•		•	
Pedicularis lanceolata					•	•	•									•	•	•				•		•	
Peltandra virginica								•		•	•														•
Penthorum sedoides		•			•	•			•									•						•	

	Suppliers																								
Wetland forb species, cont.	Bf	Bp	Cr	Cw	Gn	Ie	Ip	Jj	Jn	Kw	Lh	Lv	Ma	Me	Mw	Ng	Pf	Pm	Pn	Pp	Pr	Ps	Ss	Tc	Wn
Phlox glabberima		•														•		•					•	•	
Phlox maculata						•	•								•								•		
Physostegia virginiana	•	•	•		•	•	•				•	•	•			•	•	•	•	•	•		•	•	
Polygonum spp.				•			•	•	•	•	•		•	•										•	•
Pontedaria cordata				•		•	•	•		•	•		•			•							•		•
Prenanthes racemosa						•	•										•	•				•		•	
Pycnanthemum virginianum	•	•	•	•	•	•	•				•	•		•		•	•	•			•	•		•	
Rudbeckia laciniata	•	•		•	•	•					•						•	•	•				•	•	
Rumex orbiculatus				•	•	•								•							•			•	
Rumex verticillatus					•				•					•				•						•	
Sagittaria latifolia				•	•	•	•		•	•	•		•	•		•		•					•	•	•
Saxifraga pensylvanica						•										•	•	•				•			
Scutellaria epilobiifolia					•		•											•							
Silphium perfoliatum		•		•	•	•	•				•			•		•	•	•	•	•	•	•		•	
Solidago gigantea					•	•					•			•										•	
Solidago graminifolia	•	•		•	•	•	•							•		•	•	•			•			•	
Solidago patula					•											•									
Solidago riddellii			•	•	•	•					•		•	•	•	•		•	•		•	•		•	
Sparganium eurycarpum				•		•	•	•		•	•		•	•		•		•			•			•	•
Thalictrum dasycarpum	•		•	•	•	•	•				•			•		•	•	•	•		•	•		•	
Typha angustifolia							•	•		•			•	•		•									
Typha latifolia				•	•		•	•		•	•		•	•				•					•		•
Verbena hastata		•		•	•	•	•		•		•		•	•		•	•	•	•		•		•	•	
Vernonia fasciculata	•		•	•	•	•	•			•	•			•		•	•	•	•	•	•			•	
Vernonia missurica		•			•	•												•							
Veronicastrum virginicum	•	•	•	•	•	•	•				•	•		•		•	•	•	•		•	•	•	•	
Zizia aurea		•			•	•	•				•	•				•	•	•	•	•	•	•		•	

Suppliers

Submergent and emergent aquatic species	Bf	Bp	Cr	Cw	Gn	Ie	Ip	Jj	Jn	Kw	Lh	Lv	Ma	Me	Mw	Ng	Pf	Pm	Pn	Pp	Pr	Ps	Ss	Tc	Wn
Nelumbo lutea								•		•	•														•
Nuphar luteum				•				•		•	•		•												•
Nymphaea spp.				•				•		•	•		•			•									•
Floating or submerged species								•		•	•		•												•
(including Ceratophyllum, Elodea, Lemna, Najas, Potamogeton spp., aquatic Ranunculus, Spirodela, Vallisneria, and Wolffia)																									
Wetland grass species																									
Bromus ciliatus					•									•			•	•				•		•	
Calamagrostis canadensis		•	•	•	•	•	•	•			•		•	•		•	•	•	•		•	•	•	•	•
Chasmanthium latifolium		•			•				•		•				•	•							•		
Cinna arundinacea					•											•									
Elymus virginicus					•	•					•			•		•		•	•		•		•	•	
Glyceria striata		•		•	•	•					•		•	•		•		•	•		•		•	•	
Hierochloe odorata		•										•				•	•	•	•		•			•	
Leersia oryzoides				•		•		•	•	•	•		•	•				•			•			•	•
Panicum virgatum		•	•		•	•	•	•	•	•	•			•	•	•	•	•	•		•	•	•	•	•
Phragmites communis				•				•		•	•		•	•								•			•
Spartina pectinata	•	•	•	•	•	•	•	•		•	•	•	•	•		•	•	•	•		•	•	•	•	•
Tripsacum dactyloides		•			•										•			•					•		
Zizania aquatica								•		•			•												•
Sedge species																									
Carex annectens		•			•						•			•		•		•						•	
Carex aquatilis			•	•	•			•		•			•	•							•				
Carex atherodes				•	•								•			•									
Carex bebbii			•	•	•			•					•	•		•			•					•	
Carex bicknellii		•	•		•						•					•	•				•	•		•	
Carex buxbaumii		•			•																				
Carex comosa				•	•	•		•		•	•		•	•		•		•			•			•	
Carex crinita		•		•		•			•				•	•		•		•			•			•	
Carex cristatella		•		•	•	•					•		•			•									
Carex crus-corvi		•			•											•									

	Suppliers																								
Sedge species, cont.	Bf	Bp	Cr	Cw	Gn	Ie	Ip	Jj	Jn	Kw	Lh	Lv	Ma	Me	Mw	Ng	Pf	Pm	Pn	Pp	Pr	Ps	Ss	Tc	Wn
Carex frankii		•							•							•							•		
Carex granularis		•	•	•	•									•											
Carex grayi				•					•		•													•	
Carex hystricina			•	•				•			•		•	•				•	•		•			•	
Carex lacustris		•		•		•	•	•		•	•		•	•		•		•	•		•			•	•
Carex lanuginosa		•		•	•								•	•		•								•	
Carex lupulina						•		•	•		•		•			•		•						•	
Carex lurida		•							•																
Carex muhlenbergii		•						•			•							•						•	
Carex pensylvanica		•		•								•	•			•			•		•				
Carex retrorsa				•				•						•		•		•			•				
Carex sartwellii				•				•								•									
Carex scoparia				•	•			•	•				•	•		•		•			•			•	
Carex sprengelii					•											•		•						•	
Carex stipata				•	•	•					•		•	•		•		•			•			•	
Carex stricta		•	•	•		•		•		•	•		•	•		•		•			•			•	
Carex trichocarpa				•	•								•								•				
Carex vulpinoidea		•	•	•	•	•		•	•		•		•	•		•		•	•		•		•	•	
Cyperus spp.								•	•	•	•														•
Eleocharis acicularis				•				•		•			•					•							•
Eleocharis palustris								•		•	•		•												•
Scirpus acutus				•	•	•		•		•			•	•		•		•						•	•
Scirpus americanus				•				•		•			•											•	•
Scirpus atrovirens		•		•	•	•	•	•	•	•	•		•	•		•		•			•		•	•	•
Scirpus cyperinus				•	•	•		•	•	•			•	•				•			•			•	•
Scirpus fluviatilis				•				•		•	•		•	•		•								•	•
Scirpus pendulus (lineatus)		•		•				•						•										•	
Scirpus tabernaemontanii (validus)				•	•	•		•	•	•	•		•	•		•		•			•		•	•	•

	Suppliers																								
Wetland rush species	Bf	Bp	Cr	Cw	Gn	Ie	Ip	Jj	Jn	Kw	Lh	Lv	Ma	Me	Mw	Ng	Pf	Pm	Pn	Pp	Pr	Ps	Ss	Tc	Wn
Juncus balticus				•				•					•												
Juncus dudleyi				•				•						•				•						•	
Juncus effusus				•				•	•	•			•	•				•					•	•	•
Juncus nodosus				•				•										•							
Juncus tenuis				•				•					•	•		•		•							
Juncus torreyi		•		•	•			•		•			•	•				•						•	•
Wetland shrubs																									
Amorpha fruticosa		•			•	•					•					•		•					•	•	
Cephalanthus occidentalis		•		•	•	•		•	•		•	•	•		•	•		•					•		•
Cornus obliqua (amomum)				•				•										•					•		
Cornus racemosa								•			•	•						•				•			
Cornus sericea (stolonifera)				•				•		•	•	•						•							
Ilex verticillata											•	•						•							
Lindera benzoin											•				•								•		
Physocarpus opulifolius					•	•			•		•	•			•			•							
Rosa palustris					•				•									•							
Spiraea alba				•	•	•	•						•	•		•		•						•	
Spiraea tomentosa				•									•	•		•					•		•		
Nonwetland prairie grasses																									
Andropogon gerardii	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•	•
Bouteloua curtipendula		•	•	•	•	•	•				•	•		•	•	•	•	•	•	•	•	•	•	•	
Bromus kalmii		•			•						•					•	•	•			•			•	
Danthonia spicata		•			•						•											•			
Elymus canadensis	•	•			•	•	•				•			•		•	•	•	•		•	•		•	
Elymus hystrix (H. patula)	•	•		•	•	•			•		•			•		•	•	•			•	•		•	
Eragrostis spectabilis											•					•	•	•	•		•	•			
Koeleria macrantha (cristata)	•	•	•		•	•	•				•					•	•	•	•		•	•	•	•	
Schizachyrium scoparium	•	•	•	•	•	•	•	•		•	•	•		•	•	•	•	•	•	•	•	•	•	•	•
Sorghastrum nutans	•	•	•	•	•	•	•			•	•	•		•	•	•	•	•	•	•	•	•	•	•	•
Sporobolus asper		•				•					•						•	•					•		
Sporobolus heterolepis	•	•	•	•	•	•	•				•	•			•	•	•	•	•	•	•	•		•	

	Suppliers																								
Nonwetland prairie grasses, cont.	Bf	Bp	Cr	Cw	Gn	Ie	Ip	Jj	Jn	Kw	Lh	Lv	Ma	Me	Mw	Ng	Pf	Pm	Pn	Pp	Pr	Ps	Ss	Tc	Wn
Stipa spartea	•	•			•	•	•				•						•	•			•	•		•	
Nonwetland prairie forbs and shrubs																									
Allium canadense		•			•	•										•	•	•			•	•		•	
Allium cernuum	•	•	•		•						•	•				•	•	•	•		•	•	•	•	
Amorpha canescens		•	•		•	•	•				•	•				•	•	•	•		•	•	•	•	
Anemone cylindrica		•	•	•	•	•	•				•			•		•	•	•	•		•	•		•	
Antennaria neglecta																	•	•			•	•		•	
Aquilegia canadensis	•	•	•	•	•	•	•	•	•			•		•	•	•	•	•	•	•	•			•	
Asclepias sullivantii		•			•	•					•					•		•			•				
Asclepias tuberosa	•	•	•	•	•	•	•		•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	
Asclepias verticillata				•	•	•	•	•			•	•	•	•		•	•	•	•		•	•		•	
Aster azureus	•		•	•	•	•	•				•	•				•		•	•		•	•	•	•	
Aster ericoides		•	•		•	•	•									•		•			•	•		•	
Aster laevis	•	•	•	•	•	•					•	•		•	•	•	•	•	•	•	•	•	•	•	
Aster oblongifolius	•	•			•											•		•			•		•		
Aster (Solidago) ptarmicoides	•	•	•		•	•	•					•				•	•	•	•		•	•		•	
Aster sericeus	•	•			•	•	•								•	•	•	•	•		•	•	•	•	
Astragalus canadensis					•	•	•									•	•	•				•	•		
Baptisia leucantha (lactea)	•	•	•	•	•	•	•				•	•			•	•	•	•	•		•	•	•	•	
Baptisia leucophaea	•	•	•	•	•	•	•									•	•	•	•		•	•	•	•	
Blephilia ciliata		•			•				•							•		•				•	•	•	
Cacalia atriplicifolia					•												•	•	•			•			
Camassia scilloides		•			•				•		•							•					•		
Cassia fasciculata	•	•			•	•	•		•	•	•					•	•	•			•		•	•	•
Ceanothus americanus	•	•	•	•	•	•	•				•	•			•	•	•	•	•		•	•	•	•	
Coreopsis palmata	•	•	•	•	•	•	•				•	•			•	•	•	•	•		•	•		•	
Coreopsis tripteris		•			•	•					•					•		•	•				•	•	
Desmanthus illinoensis		•			•	•					•							•					•	•	
Desmodium canadense	•	•	•		•	•	•				•	•		•		•	•	•	•		•	•		•	
Desmodium illinoense					•	•	•				•			•		•	•	•			•	•		•	

	Suppliers																								
Nonwetland prairie forbs and shrubs, cont.	Bf	Bp	Cr	Cw	Gn	Ie	Ip	Jj	Jn	Kw	Lh	Lv	Ma	Me	Mw	Ng	Pf	Pm	Pn	Pp	Pr	Ps	Ss	Tc	Wn
Dodecatheon media	•	•	•		•	•	•	•			•	•				•	•	•	•		•	•	•	•	
Echinacea pallida		•	•		•	•	•				•	•			•	•	•	•	•	•	•	•	•	•	
Echinacea purpurea	•	•	•	•	•	•			•		•	•	•	•	•	•	•	•	•	•	•		•	•	
Eryngium yuccifolium	•	•	•		•	•	•				•	•		•	•	•	•	•	•	•	•	•	•	•	
Euphorbia corollata					•	•	•					•				•	•	•	•		•	•	•	•	
Fragaria virginiana		•										•						•			•	•	•	•	
Galium boreale					•	•	•									•	•	•			•	•		•	
Gentiana puberulenta	•						•				•						•		•			•		•	
Geum triflorum	•	•	•		•	•	•					•				•	•	•	•	•	•	•		•	
Helianthus mollis		•													•	•		•	•				•	•	
Helianthus occidentalis	•	•				•					•				•	•	•	•	•	•	•	•	•	•	
Helianthus rigidus (laetiflorus)	•	•			•	•	•									•		•	•		•	•		•	
Helianthus strumosus					•							•						•	•		•	•		•	
Heliopsis helianthoides	•	•	•	•	•	•			•		•	•			•	•	•	•	•	•	•	•	•	•	
Heuchera richardsonii	•	•	•		•	•	•					•			•	•	•	•	•		•	•		•	
Hypoxis hirsuta						•			•							•		•						•	
Kuhnia (Brickellia) eupatorioides	•				•	•	•				•					•	•	•			•	•	•	•	
Lespedeza capitata		•	•		•	•	•				•			•	•	•	•	•	•		•	•	•	•	
Liatris aspera	•	•	•	•	•	•	•			•	•	•	•	•	•	•	•	•	•		•	•	•	•	
Liatris cylindracea		•	•		•	•	•									•	•	•	•		•	•	•	•	
Liatris pycnostachya	•	•	•	•	•	•	•				•	•		•	•	•	•	•	•		•	•	•	•	
Liatris spicata		•		•		•					•					•		•	•		•	•	•	•	
Lobelia spicata						•	•									•		•				•	•	•	
Lupinus perennis	•				•	•					•	•					•	•	•		•	•	•	•	
Monarda fistulosa	•	•	•	•	•	•	•		•		•	•		•	•	•	•	•	•	•	•	•	•	•	
Oenothera biennis		•		•	•	•	•		•					•			•	•			•	•		•	
Parthenium integrifolium	•	•	•		•	•	•				•	•			•	•	•	•	•	•	•	•	•	•	
Penstemon digitalis		•	•		•	•									•	•	•	•	•		•	•	•	•	
Petalostemum candidum	•	•	•		•	•	•				•				•	•	•	•	•		•	•	•	•	
Petalostemum purpureum	•	•	•	•	•	•	•				•	•		•	•	•	•	•	•		•	•	•	•	•
Phlox pilosa	•		•			•	•					•			•	•	•	•			•	•	•	•	

Nonwetland prairie forbs and shrubs, cont.	Suppliers																								
	Bf	Bp	Cr	Cw	Gn	Ie	Ip	Jj	Jn	Kw	Lh	Lv	Ma	Me	Mw	Ng	Pf	Pm	Pn	Pp	Pr	Ps	Ss	Tc	Wn
Potentilla arguta	•	•			•	•	•				•					•	•	•			•	•		•	
Ratibida pinnata	•	•	•	•	•	•	•		•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	
Rosa spp.					•	•	•				•	•			•	•	•	•			•	•	•	•	
Rudbeckia hirta	•	•	•	•	•	•	•		•		•	•			•	•	•	•	•	•	•	•	•	•	
Rudbeckia subtomentosa	•	•	•	•	•	•					•	•			•	•	•	•	•		•		•	•	
Rudbeckia triloba		•			•	•					•	•			•	•	•	•	•				•	•	
Silphium integrifolium		•		•	•	•					•					•	•	•	•		•	•	•	•	
Silphium laciniatum	•	•	•	•	•	•	•				•	•			•	•	•	•	•	•	•	•	•	•	
Silphium terebinthinaceum		•	•	•	•	•					•	•		•	•	•	•	•	•	•	•	•	•	•	
Sisyrinchium spp.	•	•	•			•	•										•	•	•		•	•	•	•	
Solidago rigida	•	•	•	•	•	•	•				•	•		•	•	•	•	•	•		•	•	•	•	
Solidago speciosa	•	•	•	•	•	•			•		•	•	•			•	•	•	•		•	•		•	
Tradescantia ohiensis	•	•	•		•	•	•	•		•	•	•		•	•	•	•	•	•	•	•	•	•	•	
Viola pedata	•											•					•	•	•			•	•	•	
Zizia aptera			•		•	•	•				•					•	•	•	•		•	•		•	

Suppliers of Illinois Native Plant Species

The listing of a nursery does not constitute an endorsement of the nursery or guarantee the quality of its products or services. Species listed for a particular nursery are from the most recent catalog available. Comments are from information provided in catalogs and sometimes from a letter written by a supplier describing its services. For more information, please contact individual suppliers.

Code	Supplier Name	Comments
Bf	Bluestem Farm S5920 Lehman Rd Baraboo, WI 53913 Tel: 608-356-0179	Retail. Sells prairie and some woodland and wetland species of primarily southwestern Wisconsin origin. Bulk quantities of grasses and contract growing of seeds also available.
Bp	Bluestem Prairie Nursery Ken Schaal Rural Route 2 Box 106-A Hillsboro, IL 62049 Tel: 217-532-6344	Mail order, retail. Sells wide variety of native plants and seeds, almost entirely of Illinois ecotypes. Seed mixes are available.
Cr	Country Road Greenhouses, Inc. 19561 E. Twombly Rochelle, IL 61068 Tel: 815-384-3311	Wholesale. Sells plugs of prairie and some wetland species. Provides contract growing and consultation.
Cw	Country Wetlands Nursery & Consulting, Ltd. P.O. Box 337 Muskego, WI 53150-0337 Tel: 414-679-1268 FAX: 414-679-1279	Mail order, retail, and wholesale. Sells seeds and plants of wetland species, with some prairie and woodland species. Also performs consulting and restoration, including site evaluation, hydrogeological assessment, project design assistance, site maintenance, and pond emplacement.
Gn	Genesis Nursery, Inc. Tampico, IL 61283 Tel: 815-438-2220	Mail order, retail, and wholesale. Sells seeds, seed mixes, and plants of prairie, wetland, and woodland species. Also provides consultation and designs projects.
Ie	Ion Exchange Howard & Donna Bright 1878 Old Mission Drive Harpers Ferry, IA 52146 Tel: 319-535-7231 800-291-2143 FAX: 319-535-7362	Mail order, retail, and wholesale. Sells seeds, seed mixes, and plants of prairie, wetland, and woodland species. Seeds are from propagated plants or are collected within a 150-mile radius. Also provides prairie and wetland restoration, landscaping, and consulting.
Ip	Iowa Prairie Seed Company P.O. Box 228 Sheffield, IA 50475 Tel: 515-892-4111	Mail order, retail, and wholesale. Sells seeds, seed mixes, and plants of native Iowa prairie species, with some woodland and wetland species. Provides onsite consulting and assistance with prescribed burns.
Jj	J & J Tranzplant Aquatic Nursery James and Kristine Malchow P.O. Box 227 Wild Rose, WI 54984-0227 Tel: 414-622-3552 800-622-5055 for orders only FAX: 414-622-3660	Mail order, retail, and wholesale. Offers mostly plants and rootstocks of wetland and aquatic plants, with some prairie and woodland species, all collected from mananged private sites.
Jn	Jane's Native Seeds 1860 Kay's Branch Rd. Owenton, KY 40359 Tel: 502-484-2578, 2044	Mail order, retail. Offers seed of wetland, prairie, and woodland species. Also supplies some seed for Shooting Star Nursery.

Suppliers of Illinois Native Plants (continued)

Code	Supplier Name	Comments
Kw	Kester's Wild Game Food Nurseries, Inc. David & Patricia Kester P.O. Box 516 Omro, WI 54963 Tel: 414-685-2929 800-558-8815 for orders only FAX: 414-685-6727	Mail order, retail, and wholesale. Among the oldest game food nurseries. Offers mostly plants and rootstocks of wetland and aquatic plants, with some prairie and woodland species, as well as a variety of non-native legumes and cover crops for wildlife food and erosion control.
Lh	LaFayette Home Nursery LaFayette, IL 61449 Tel: 309-995-3311 FAX: 309-995-3909	Retail and wholesale. Sells seeds and plants. Seeds are generally sold only as components of a variety of packaged mixes. Some are grown on site; many seeds are obtained from managed collection sites scattered in Illinois. Also offers a large number of shrub and tree species. Provides habitat and wetland restoration, landscaping, design, and consulting.
Lv	Little Valley Farm Route 3 Box 544 Snead Creek Road Spring Green, WI 53588 Tel: 608-935-3324	Mail order and retail. Offers plants and seeds of prairie, wetland, and woodland species, including a number of ferns, forbs, and shrub species not included in the table.
Ma	Midwest Aquatics Route 3, Box 360-5 Wautoma, WI 54982 Tel: 414-787-3282	Mail order, retail, wholesale. Offers seeds and plants, mainly for wetland and aquatic habitats. Involved with wetland restoration and mitigation and with wildlife habitat enhancement.
Me	Murn Environmental, Inc. 10282 Riverview Dr. Edgerton, WI 53534 Tel: 608-884-6563 414-473-2737 FAX: 608-884-6678	Mail order, retail, wholesale. Offers Wisconsin origin seeds and plants for wetland and prairie species. Also offers natural landscaping design, installation, and management and wetlands delineation, assessment, and mitigation.
Mw	Missouri Wildflowers Nursery 9814 Pleasant Hill Rd. Jefferson City, MO 65109 Tel: 314-496-3492	Mail order, retail. Offers prairie, glade, and some wetland species native to Missouri. Plants, seeds, and seed mixes. Provides landscaping.
Ng	The Natural Garden 38W443 Highway 64 St. Charles, IL 60175 Tel: 708-584-0150 FAX: 708-584-0185	Mail order, retail, and wholesale. Offers plants and seeds of prairie, wetland, and woodland species, in addition to native ferns and a variety of ornamental and bedding plants. Also performs consulting, landscaping, and restoration.
Pf	Prairie Future Seed Company P.O. Box 644 Menomonee Falls, WI 53052-0644 Tel: 414-491-0685	Mail order, retail. Offers seeds of prairie, and some wetland and woodland species. Also offers seeds of native shrubs and trees. Provides consultation and site management.
Pm	Prairie Moon Nursery Alan Wade Route 3 Box 163 Winona, MN 55987 Tel: 507-452-1362	Mail order, retail, and wholesale. Plants native to the driftless region, including northern Illinois. Sells seeds, seed mixes, and plants of prairie, wetland, and woodland species. Provides consultation.

Suppliers of Illinois Native Plants (continued)

Code	Supplier Name	Comments
Pn	Prairie Nursery P.O. Box 306 Westfield, WI 53964 Tel: 608-296-3679 FAX: 608-296-2741	Mail order, retail. Sells seeds, seed mixes, and plants of prairie and wetland species. Provides prairie restoration, landscaping, design, and consultation.
Pp	The Prairie Patch James Maddox RR1 Box 41 Niantic, IL 62551 Tel: 217-668-2409	Retail. Small firm which sells plugs of prairie plants native to central Illinois. Also performs restoration.
Pr	Prairie Ridge Nursery RR2 9738 Overland Road Mt. Horeb, WI 53572-2382 Tel: 608-437-5245 FAX: 608-437-8982	Mail order, retail, and wholesale. Offers seeds and plants of southwestern Wisconsin ecotype prairie and wetland species. A division of CRM Ecosystems, which performs consulting, restoration, and landscape management.
Ps	Prairie Seed Source P.O. Box 83 North Lake, WI 53064-0083	Mail order. Wide variety of prairie and oak openings grasses and forbs. Seeds and seed mixes. Has the most restrictive definition of local ecotypes, reaching only into McHenry and Lake counties in Illinois. Provides prairie restoration and consulting.
Ss	Shooting Star Nursery 444 Bates Road Frankfort, KY 40601 Tel: 502-223-1679	Mail order, retail, and wholesale. Offers seeds, seed mixes, and plants for prairie, wetlands, and woodland. Also offers some shrub and tree species. A division of Ecological Stewardship Services, which provides habitat and wetland restoration, consultation, design, and biological assessment.
Tc	Taylor Creek Restoration Nurseries owned and operated by Applied Ecological Services, Inc. 17921 Smith Road P.O. Box 256 Brodhead, WI 53520 Tel: 608-897-8641 FAX: 608-897-8486	Mail order, retail, and wholesale. Nursery itself is relatively new, but the company has been involved with wetland, prairie, and savanna restoration and creation for years. Performs consultations and design and implements restoration plans, mostly in Wisconsin and northern Illinois, but also in other states.
Wn	Wildlife Nurseries, Inc. P.O. Box 2724 Oshkosh, WI 54903-2724 Tel: 414-231-3780 FAX: 414-231-3554	Mail order, retail, and wholesale. Among the oldest game food nurseries. Offers mostly plants and rootstocks of wetland and aquatic plants, with some prairie and woodland species, as well as a variety of non-native legumes and cover crops for wildlife food and erosion control.

LaFayette Home Nursery offers a wide variety of native tree species. Shooting Star Nursery also offers native trees, and Country Wetlands Nursery, Little Valley Farm, and Missouri Wildflowers Nursery offer native shrubs.

Some additional nurseries that primarily offer native and non-native woody species include:

Cascade Forestry Nursery
22033 Fillmore Road
Cascade, IA 52033
Tel: 319-852-3042
FAX: 319-852-5004

Forrest Keeling Nursery
Hwy 79 S., P.O. Box 135
Elsberry, MO 63343
Tel: 314-898-5571

Reeseville Ridge Nursery
P.O. Box 171, 309 S. Main St.
Reeseville, WI 53579
Tel: 414-927-3291

Smith Nursery
P.O. Box 515
Charles City, IA 50616
Tel: 515-228-3239

Listed below are some other nurseries that primarily offer prairie species.

Feder's Prairie Seed Co.
Route 1, Box 41
Blue Earth, MN 56013
Tel: 507-526-3049

Hamilton Seeds & Wildflowers
Rex & Amy Hamilton
16786 Brown Road
Elk Creek, MO 65464
Tel: 417-967-2190

The Prairie Garden
705 S. Kenilworth
Oak Park, IL 60304
Tel: 708-386-7495

Prairie Hill Wildflowers
RR1, Box 191 A
Ellendale, MN 56026
Tel: 507-451-7791

Windsong Prairie Nursery
5412 Ridgeway Road
Ringwood, IL 60072
Tel: 815-653-6936

The Michigan Wildflower Farm
11770 Cutler Road
Portland, MI 48875-9452
Tel: 517-647-6010

Marty Lucas
Route 1, Box 77E
North Judson, IN 46366
Tel: 219-896-5574

Kettle Moraine Natural Landscaping
W996 Birchwood Drive
Campbellsport, WI 53010
Tel: 414-533-8939

Purple Prairie Farm
Route 2, Box 176
Wyoming, IL 61491
Tel: 309-286-7356
(wholesale only)

Appendix O: Scientific and Common Plant Names

The following list includes scientific and common names of species mentioned in this Guide.

Acer negundo	box elder
Acer rubra	red maple
Acer saccharinum	silver maple
Acorus americanus	flag root
Acorus calamus	sweetflag
Agropyron repens	quack grass
Alisma plantago-aquatica	broad-leaf water plantain
Allium canadense	wild garlic
Allium cernuum	nodding wild onion
Amaranthus tuberculatus	water hemp
Amorpha canescens	leadplant
Amorpha fruticosa	false indigo-bush
Ambrosia artemisiifolia	common ragweed
Ambrosia trifida	giant ragweed
Amsonia tabernaemontana	blue star
Andropogon gerardii	big bluestem
Anemone canadensis	Canada anemone
Anemone cylindrica	thimbleweed
Angelica atropurpurea	angelica
Antennaria neglecta	pussytoes
Aquilegia canadensis	wild columbine
Arisaema triphyllum	Jack-in-the-pulpit
Asclepias incarnata	swamp milkweed
Asclepias sullivantii	prairie milkweed
Asclepias tuberosa	butterflyweed
Asclepias verticillata	horsetail milkweed
Aster azureus	sky-blue aster
Aster ericoides	heath aster
Aster laevis	smooth aster
Aster lateriflorus	calico aster
Aster novae-angliae	New England aster
Aster oblongifolius	aromatic aster
Aster prenanthoides	crooked aster
Aster praeltus	willow aster
Aster (Solidago) ptarmicoides	stiff aster
Aster puniceus	swamp aster
Aster sericeus	silky aster
Aster simplex	panicled aster
Aster umbellatus	flattop aster
Astragalus canadensis	Canadian milk vetch
Baptisia leucantha (lactea)	white wild indigo
Baptisia leucophaea	cream wild indigo
Betula nigra	river birch
Bidens aristosa	swamp marigold
Bidens cernua	nodding bur marigold
Bidens connata	swamp beggar-tick
Bidens coronata	tall swamp marigold
Bidens frondosa	common beggar-ticks
Bidens tripartita	beggar-ticks
Blephilia ciliata	Ohio horsemint
Boltonia asteroides	false-aster
Bouteloua curtipendula	sideoats grama
Bromus ciliatus	Canada brome grass
Bromus kalmii	prairie brome
Cacalia atriplicifolia	pale Indian plantain
Cacalia suaveolens	sweet Indian plantain
Calamagrostis canadensis	bluejoint grass
Calla palustris	water arum
Caltha palustris	marsh marigold
Camassia scilloides	wild hyacinth
Carex annectens	sedge
Carex aquatilus	sedge
Carex atherodes	sedge
Carex bebbii	Bebb's sedge
Carex bicknellii	Bicknell's sedge
Carex buxbaumii	Buxbaum's sedge
Carex comosa	bristly sedge
Carex crinita	fringed sedge
Carex cristatella	sedge
Carex crus-corvi	sedge
Carex frankii	sedge
Carex granularis	sedge
Carex gravida	sedge
Carex grayi	bur sedge
Carex hystricina	bottlebrush sedge
Carex lacustris	lake sedge
Carex lanuginosa	woolly sedge
Carex lupulina	hop sedge
Carex lurida	sedge
Carex muhlenbergii	sedge
Carex pensylvanica	Pennsylvania sedge
Carex retrorsa	sedge
Carex sartwellii	Sartwell's sedge
Carex scoparia	broom sedge
Carex sprengelii	long-beaked sedge
Carex squarrosa	squarrose sedge
Carex stipata	sedge
Carex stricta	tussock sedge
Carex trichocarpa	sedge
Carex vulpinoidea	fox sedge
Cassia fasciculata	partridge pea
Cassia hebecarpa	wild senna
Cassia marilandica	Maryland senna
Castilleja coccinea	Indian paintbrush
Ceanothus americanus	New Jersey tea
Celtis occidentalis	hackberry
Cephalanthus occidentalis	buttonbush
Ceratophyllum demersum	coontail
Chasmanthium latifolium	sea-oats
Chelone glabra	white turtlehead
Chenopodium glaucum	oak-leaved goosefoot
Cicuta maculata	spotted water hemlock
Cinna arundinacea	tall wood reed
Cirsium arvense	field thistle
Cirsium muticum	swamp thistle
Coreopsis palmata	prairie coreopsis
Coreopsis tripteris	tall coreopsis
Cornus amomum	pale dogwood
Cornus obliqua	pale dogwood
Cornus racemosa	gray dogwood
Cornus sericea (stolonifera)	red-osier dogwood
Cyperus erythrorhizos	red-rooted sedge
Cyperus esculentus	yellow nutsedge
Cyperus strigosus	straw nutsedge
Dalea candida (Petalostemum candidum)	white prairie clover

Dalea purpurea (Petalostemum purpureum)	purple prairie clover
Danthonia spicata	poverty oat grass
Decodon verticillatus	swamp loosestrife
Desmanthus illinoensis	Illinois bundleflower
Desmodium canadense	showy tick trefoil
Desmodium illinoense	Illinois tick trefoil
Dodecatheon meadia	shooting star
Echinacea pallida	pale purple coneflower
Echinacea purpurea	broad-leaved purple coneflower
Echinochloa crus-galli	barnyard grass
Eleocharis acicularis	needle spike rush
Eleocharis erythropoda	spike rush
Eleocharis obtusa	spike rush
Eleocharis palustris	spike rush
Elodea canadensis	waterweed
Elodea nuttallii	waterweed
Elymus canadensis	Canada wild rye
Elymus hystrix	bottlebrush grass
Elymus virginicus	Virginia wild rye
Epilobium coloratum	willow-herb
Eragrostis spectabilis	purple love grass
Erigeron philadelphicus	marsh fleabane
Eryngium yuccifolium	rattlesnake master
Eupatorium coelestinum	blue boneset
Eupatorium maculatum	spotted Joe-pye-weed
Eupatorium perfoliatum	boneset
Eupatorium purpureum	purple Joe-pye-weed
Euphorbia corollata	flowering spurge
Fragaria virginiana	wild strawberry
Fraxinus pennsylvanica	green ash
Galium boreale	northern bedstraw
Gentiana andrewsii	closed gentian
Gentiana puberulenta	downy gentian
Gentianopsis crinita	fringed gentian
Gerardia (Agalinis) tenuifolia	slender false foxglove
Geum triflorum	prairie avens
Glyceria striata	fowl manna grass
Helenium autumnale	common sneezeweed
Helianthus grosseserratus	sawtooth sunflower
Helianthus mollis	downy sunflower
Helianthus occidentalis	western sunflower
Helianthus rigidus (laetiflorus)	prairie sunflower
Helianthus strumosus	pale-leaved sunflower
Heliopsis helianthoides	false sunflower
Heracleum lanatum	cow parsnip
Heuchera richardsonii grayana	prairie alumroot
Hibiscis laevis	halberd-leaf rosemallow
Hibiscus lasiocarpus	hairy rose mallow
Hibiscus palustris (moschuetos)	swamp rose mallow
Hierochloe odorata	sweet grass
Hydrophyllum virginianum	Virginia waterleaf
Hypericum pyramidatum	giant St. Johns-wort
Hypoxis hirsuta	yellow star grass
Ilex verticillata	winterberry
Impatiens capensis (biflora)	orange jewelweed
Iris fulva	swamp red iris
Iris (virginica) shrevei	blue flag
Juglans nigra	black walnut
Juncus balticus littoralis	baltic rush
Juncus dudleyi	Dudley's rush
Juncus effusus	common rush
Juncus interior	inland rush
Juncus nodosus	knotted rush
Juncus tenuis	path rush
Juncus torreyi	Torrey's rush
Koeleria macrantha	crested hair grass
Kuhnia (Brickellia) eupatorioides	false boneset
Leersia oryzoides	rice cutgrass
Lemna minor	common duckweed
Lemna trisulca	ivy-leaved duckweed
Lespedeza capitata	bush clover
Liatris aspera	rough blazing star
Liatris cylindracea	blazing star
Liatris pycnostachya	prairie blazing star
Liatris spicata	marsh blazing star
Lilium michiganense	Turk's cap lily
Lindera benzoin	spicebush
Liquidambar styaciflua	sweet gum
Lobelia cardinalis	cardinal flower
Lobelia siphilitica	great blue lobelia
Lobelia spicata	pale spiked lobelia
Ludwigia alternifolia	seedbox
Ludwigia palustris	marsh purslane
Lupinus perennis	wild lupine
Lycopus americanus	American bugleweed
Lycopus virginicus	Virginia bugleweed
Lysimachia quadrifolia	whorled loosestrife
Lysimachia quadriflora	narrow-leaved loosestrife
Lysimachia terrestris	swamp candles
Lysimachia thrysiflora	tufted loosestrife
Lythrum alatum	winged loosestrife
Lythrum salicaria	purple loosestrife
Melilotus alba	white sweet clover
Mertensia virginica	Virginia bluebells
Mimulus ringens	monkey flower
Monarda fistulosa	wild bergamot
Myriophyllum spp.	water milfoil
Najas flexilis	bushy pondweed
Napaea dioica	glade mallow
Nelumbo lutea	American lotus
Nuphar luteum macrophyllum	spatterdock
Nymphaea tuberosa	white water lily
Oenothera biennis	evening primrose
Oxypolis rigidior	cowbane
Panicum virgatum	switch grass
Parthenium integrifolium	American feverfew
Pedicularis lanceolata	swamp wood betony
Peltandra virginica	arrow arum
Penstemon digitalis	foxglove beard-tongue
Penthorum sedoides	ditch stonecrop
Phalaris arundinacea	reed canary grass
Phlox glaberrima interior	smooth phlox
Phlox maculata	wild sweet William
Phlox pilosa	downy phlox
Phragmites australis	common reed
Physalis virginiana	ground cherry
Physocarpus opulifolius	common ninebark
Physostegia virginiana	false dragonhead
Platanus occidentalis	sycamore
Polygonum amphibium	water smartweed

Polygonum hydropiper	marshpepper
Polygonum pensylvanicum	smooth smartweed
Polygonum punctatum	smartweed
Pontederia cordata	pickerelweed
Populus deltoides	eastern cottonwood
Populus heterophylla	swamp cottonwood
Potamogeton crispus	curly pondweed
Potamogeton foliosus	pondweed
Potamogeton nodosus	pondweed
Potamogeton zosteriformis	flatstem pondweed
Potentilla arguta	prairie cinquefoil
Prenanthes racemosa	glaucous white lettuce
Pycnanthemum virginianum	mountain mint
Quercus bicolor	swamp white oak
Quercus macrocarpa	bur oak
Quercus palustris	pin oak
Ranunculus flabellaris	yellow water buttercup
Ranunculus sceleratus	cursed crowfoot
Ranunculus septentrionalis	swamp buttercup
Ratibida pinnata	yellow coneflower
Rhamnus frangula	glossy buckthorn
Rosa arkansana	sunshine rose
Rosa carolina	pasture rose
Rosa palustris	swampy rose
Rudbeckia hirta	black-eyed Susan
Rudbeckia laciniata	tall coneflower
Rudbeckia subtomentosa	fragrant coneflower
Rudbeckia triloba	brown-eyed Susan
Rumex altissimus	pale dock
Rumex orbiculatus	great water dock
Rumex verticillatus	swamp dock
Sagittaria latifolia	common arrowhead
Salix exigua	sandbar willow
Salix nigra	black willow
Sambucus canadensis	elderberry
Saururus cernuus	lizard's tail
Saxifraga pensylvanica	swamp saxifrage
Schizachyrium scoparium	little bluestem
Scirpus acutus	great bulrush
Scirpus americanus	American bulrush
Scirpus atrovirens	green bulrush
Scirpus cyperinus	wool grass
Scirpus fluviatilis	river bulrush
Scirpus pendulus (lineatus)	red bulrush
Scirpus tabernaemontanii (validus)	soft-stem bulrush
Scutellaria epilobiifolia	hooded skullcap
Scutellaria lateriflora	mad-dog skullcap
Silphium integrifolium	rosinweed
Silphium laciniatum	compass plant
Silphium perfoliatum	cup plant
Silphium terebinthinaceum	prairie dock
Sisyrinchium albidum	blue-eyed grass
Sisyrinchium angustifolium	blue-eyed grass
Sium suave	water parsnip
Solidago gigantea	giant goldenrod
Solidago graminifolia	grass-leaved goldenrod
Solidago patula	spreading goldenrod
Solidago riddellii	Riddell's goldenrod
Solidago rigida	rigid goldenrod
Solidago speciosa	showy goldenrod
Sorghastrum nutans	Indian grass
Sparganium eurycarpum	burreed
Spartina pectinata	prairie cordgrass
Spiraea alba	meadow-sweet
Spiraea tomentosa	hardhack
Spirodela polyrhiza	big duckweed
Spirodela punctata	duckweed
Sporobolus asper	tall dropseed
Sporobolus heterolepis	prairie drop seed
Stachys palustris	woundwort
Stipa spartea	needle grass
Taxodium distichum	bald cypress
Teucrium canadense	American germander
Thalictrum dasycarpum	tall meadow-rue
Thelypteris palustris pubescens	marsh fern
Tradescantia ohiensis	Ohio spiderwort
Tripsacum dactyloides	gama grass
Typha angustifolia	narrowleaf cattail
Typha latifolia	common cattail
Ulmus americana	American elm
Utricularia vulgaris	common bladderwort
Vallisneria americana	eelgrass
Verbena hastata	blue vervain
Verbesina virginica	frostweed
Vernonia fasciculata	common ironweed
Vernonia missurica	Missouri ironweed
Veronicastrum virginicum	Culver's root
Viburnum dentatum	southern arrowwood
Viola pedata	birdfoot violet
Wolffia columbiana	common watermeal
Wolffiella spp.	duckweed
Zizania aquatica	giant wild rice
Zizia aptera	heart-leaved meadow parsnip
Zizia aurea	golden Alexanders

Appendix P: Growth and Propagation Requirements of Selected Wetland Plant Species

Species	Soil (substrate)	pH	Water depth range (cm)	Methods of propagation*
Herbaceous plants:				
Acorus calamus	—	5.9 - 8.8[f]	< 15[b]	R, T[b]
Alisma plantago-aquatica	—	7.0 - 8.8[f]	< 15[f]	—
Asclepias incarnata	—	—	seasonal wet soil[b]	T[b]
Bidens spp.	organic, sand, silt[ef]	—	—	S[e]
Calamagrostis canadensis	silt[c]	5 - 8[c]	wet soil to 20[c]	—
Carex stricta	—	—	< 15[b]	R, T[b]
Carex spp.	organic soil, clay[c]; peat, organic, peaty mud[f]	5 - 7.5[c]; 4.5 - 7.8[f]	wet soil to 50[c]; <15[f]	T, R, S[e]
Cyperus spp.	organic soil, clay[c]; sand, clay, silt loam[f]	3 - 8[c]	wet soil to 30[c]; <30[f]	T, W, R, Tu, S[e]
Echinochloa spp.	sand[f]	6.8 - 8.7[f]	30[f]	T[b]; S[e]
Eleocharis acicularis	peat, organic, sand, silt[f]	7.0 - 8.0[f]	<120[f]	T, R, Tu, S[e]
Eleocharis palustris	sand, silt[f]	5.9 - 9.0[f]	<50[f]	—
Hibiscus palustris (moschuetos)	peaty sand[f]	—	< 7.5[b]	T[b]
Juncus spp.	organic[c]	5 - 8[c]	wet soil to 10[c]	—
Leersia oryzoides	—	7.2 - 9.0[f]	wet soil[f]; < 7.5[b]	T, R[e]
Lobelia cardinalis	—	—	wet soil[b]	T, R[b]
Nelumbo lutea	silt, clay-organic[f]	5.3 - 6.2[f]	30 to 150[f]	T, Tu, S[e]
Nuphar luteum	organic soil, silt[c]	3 - 8[c]	50 - 200[c]; 30 -75[b]	T[b]
Panicum virgatum	—	—	wet soil to upland[b]	T[b]
Peltandra virginica	—	—	< 30[b]	Tu, R, T[b]
Phalaris arundinacea	silt loam[c]	6 - 7.5[c]	wet soil to 10[c]	—
Phragmites australis	silt, sand,clay, organic[c]; brown mud, sand, silt, clay, peaty sand[f]	3 - 8[c]; 3.7 - 9.0[f]	wet soil to 150[c]; wet soil to 200[f]	—
Polygonum amphibium	sand, silt, organic[f]	5.4 - 8.8[f]	< 200[e], < 300[f]	T, R, S[e]
Polygonum punctatum	—	—	< 15[b]	T[b]
Polygonum pensylvanicum	—	—	< 15[b]	T[b]
Polygonum spp.	silt, sand[f]	5.1 - 7.8[f]	wet soil[f]	—
Pontederia cordata	organic[f]	4.9 - 8.9[f]	<90[a]; < 30[b]; < 120[f]	R, T[b]
Potamogeton nodosus	—	7.3 - 8.5[f]	—	—
Potamogeton spp.	organic soil, silt clay[c]	4 - 10[c]	5 to 300[c]	—
Sagittaria latifolia	organic[f]	5.9 - 8.8[f]	< 60[b]; < 30[ef]	Tu[b]; T, U, S[e]
Saururus cernuus	—	—	< 30[b]	R, T[b]
Scirpus acutus	sandy or marly[a]; all[e], sand[f]	6.7 - 9.1[f]	< 150[ef]	—
Scirpus americanus	sand, clay[f]	6.7 - 8.9[f]	< 150[f]	T, R, Tu, S[e]
Scirpus fluviatilis	—	7.0 - 9.1[f]	30 to 76[a]; < 50[f]	T, R, Tu, S[e]
Scirpus tabernaemontanii	mucky[a], sand, clay, marl[f]	5.3 - 7.8[f]	< 30[b]; < 120[f]	R, T[b]; T, R, S[e]
Scirpus spp.	organic soil, clay[c]	4 - 9[c]	wet soil to 100[c]	—
Sparganium eurycarpum	—	6.7 - 8.8[f]	< 30[b]; < 120[f]	T, R, S[e]; T[b]
Spartina pectinata	sandy loam[c]	5 - 8[c]	wet soil to 50[c]	—
Typha angustifolia	organic, black mud[f]	3.7 - 8.5[f]	< 30[b]; 100[f]	R, T[b]; T, R, S[e]
Typha latifolia	organic (peat)[f]	4.5 - 9.0[f]	< 30[bf]	R, T[b]; T, R, S[e]
Verbena hastata	—	—	seasonal wet soil[b]	T[b]

Appendix P continued

Species	Soil (substrate)	pH	Water depth range (cm)	Methods of propagation*
Woody plants:				
Acer negundo	—	—	regular inundation[b]; MT[d†]	Seeds dispersed by wind and animals; germinate on moist mineral soil in shade or sun[d]
Acer rubra	—	—	seasonal inundation[b]; MT[d†]	Seeds dispersed mainly by wind, also by water and animals; germinate on moist mineral soil in shade or sun, after water recedes[d]
Acer saccharinum	—	—	seasonal inundation[b]; MT[d†]	Seeds dispersed by wind, water, and animals; seedlings grow in shade or sun[d]
Betula nigra	—	—	seasonal inundation[b]; MT[d†]	Seeds wind and water dispersed; seedlings grow on moist, well-drained soils[d]
Celtis occidentalis	—	—	MT[d†]	Seeds dispersed by water and animal; seedlings grow in full shade[d]
Cephalanthus occidentalis	—	4.9 - 8.9[f]	< 91[b]; T[d†]	Seeds dispersed by wind and water; moist seed beds optimal[d]
Cornus amomum	—	—	seasonal inundation[b]	—
Cornus racemosa	—	—	seasonal inundation[b]	—
Cornus stolonifera	—	—	seasonal inundation[b]	—
Fraxinus pennsylvanica	—	—	regular inundation[b]; MT[d†]	Seeds dispersed by wind and water; germinate on bare, moist soil[d]
Juglans nigra	—	—	WT[d†]	Seeds dispersed by gravity and animals; seedlings grow in sun[d]
Lindera benzoin	—	—	seasonal inundation[b]	—
Liquidambar styraciflua	—	—	regular inundation[b]; MT[d†]	Seeds dispersed by wind; germinate on mineral soil in the sun[d]
Platanus occidentalis	—	—	MT[d†]	Seeds dispersed by wind, water, and birds; seedlings grow on moist mudflats or exposed mineral soil[d]
Populus deltoides	—	—	WT/MT[d†]	Seeds dispersed by wind and water; germinate on moist soil[d]
Quercus bicolor	—	—	seasonal inundation[b]; MT[d†]	Seeds dispersed by gravity, rodents, and water[d]
Quercus macrocarpa	—	—	I[d†]	Seeds dispersed by gravity and animals, some by water; germinate in bottomland areas; seedlings may die if flooded during the growing season[d]
Quercus palustris	—	—	seasonal inundation[b]; MT[d†]	Seeds dispersed by animals and gravity, some by wind and water; seedlings grow in under story openings and may die if flooded during the growing season[d]

Appendix P continued

Species	Soil (substrate)	pH	Water depth range (cm)	Methods of propagation*
Rosa palustris	—	—	regular inundation[b]	—
Salix exigua	—	4.5 - 8.3[f]	MT[d]†	Seeds dispersed by wind and water; germinate best on moist, exposed mineral soil[d]
Salix nigra	—	4.5 - 8.3[f]	seasonal inundation[b]; T[d]†	Seeds dispersed by wind and water; germinate best on moist, exposed mineral soil[d]
Sambucus canadensis	—	—	seasonal inundation[b]	—
Taxodium distichum	—	—	irregular to permanent inundation[b]; T[d]†	Seeds dispersed by water; seedlings grow when water recedes[d]
Ulmus americana	—	—	seasonal inundation[b]; MT[d]†	Seeds dispersed by wind and water; germinate on moist soil[d]
Viburnum dentatum	—	—	seasonal inundation[b]	—

* Methods of propagation:
C = cuttings; R = rootstocks; S = seeds;
T = transplants; Tu = tubers; W = whole plants and fragments

†Water depth ranges:

T = tolerant; species are able to survive and grow on sites where soil is saturated or flooded for long periods during the growing season. Species have special adaptations for flood tolerance.

MT = moderately tolerant; species are able to survive saturated or flooded soils for several months during the growing season but mortality is high if flooding persists or reoccurs for several consecutive years. These species may develop some adapations for flood tolerance.

WT = weakly tolerant; species are able to survive saturated or flooded soils for relatively short periods of a few days to few weeks during the growing season; mortality is high if flooding persists longer. Species do not appear to have special adaptations for flood tolerance.

I = intolerant; species are not able to survive even short periods of soil saturation or flooding during the growing season. Species do not show special adaptations for flood tolerances.

[a] Eggers, S.D., and D.M. Reed. 1987. Wetland plants and plant communities of Minnesota and Wisconsin. U.S. Army Corps of Engineers.

[b] Environmental Concern Inc. 1993. Nursery catalog. St. Michaels, Maryland.

[c] Hammer, D.A. 1992. Creating freshwater wetlands. Lewis Publishers, Boca Raton, Florida.

[d] Haynes, R.J., J.A. Allen, and E.C. Pendleton. 1988. Reestablishment of bottomland hardwood forests on disturbed sites: an annotated bibliography. U.S. Fish and Wildlife Service Biological Report 88(42).

[e] Levine, D.A., and D.E. Willard. 1992. Regional analysis of fringe wetlands in the Midwest: a creation and restoration. pp. 299-325 *in* J.A. Kusler, and M.E. Kentula, eds. Wetland creation and restoration: the status of the science. Island Press, Washington, DC.

[f] Payne, N.F. 1992. Techniques for wildlife habitat management of wetlands. McGraw-Hill, Inc., New York.

Appendix Q: Illinois Wetland Nature Preserves

This table lists the name, natural division, county, and communities of Illinois Nature Preserves that contain wetlands. Primarily the following wetland types appear on this list: wet prairie, pond, shrub swamp, wet floodplain forest, sedge meadow, marsh, and swamp. Additional communities may be present at a preserve but are unlisted. For locations of nature preserves see *A Directory of Illinois Nature Preserves* (McFall and Karnes 1995).

Other wetland communities are described in the Illinois Natural Areas Inventory; however, these are privately owned and permission is required to enter a Natural Area. Some areas are now part of the Illinois Department of Natural Resources (IDNR) Natural Heritage Landmark program and the local IDNR Natural Heritage biologist will have information about visiting these wetlands. Heritage biologists are an excellent source of information on the flora and fauna of Illinois natural areas.

Nature Preserve	Natural division	County	Wetland communities
Searls Park Prairie	2a	Winnebago	wet prairie
Severson Dells	2a	Winnebago	wet prairie
Pecatonica Bottoms	2a	Winnebago	pond (oxbow lake), shrub swamp, wet floodplain forest
Bluff Springs Fen	3a	Cook	sedge meadow, marsh
Busse Forest	3a	Cook	marsh
Belmont Prairie	3a	Dupage	wet prairie
Churchill Prairie	3a	Dupage	sedge meadow, wet prairie
Nelson Lake Marsh	3a	Kane	pond, marsh
Burlington Prairie	3a	Kane	wet prairie, sedge meadow, marsh
Ferson's Creek Sedge Meadow	3a	Kane	sedge meadow
Almond Marsh*	3a	Lake	sedge meadow, marsh
Barrington Bog	3a	Lake	sedge meadow, marsh
Cedar Lake Bog	3a	Lake	marsh
Farm Trails North	3a	Lake	sedge meadow, marsh, wet prairie
Gavin Bog and Prairie	3a	Lake	sedge meadow, marsh
Grass Lake Marsh	3a	Lake	marsh
Highmoor Park	3a	Lake	wet prairie, sedge meadow
Hybernia	3a	Lake	wet prairie, wetland
Lyons Prairie and Marsh	3a	Lake	pond, marsh, sedge meadow, wet prairie
MacArthur Woods	3a	Lake	floodplain forest
Reed-Turner Woodland	3a	Lake	floodplain, wet meadow
Edward L. Ryerson	3a	Lake	wet floodplain forest
Skokie River	3a	Lake	wet prairie
Spring Bluff	3a	Lake	marsh
Turner Lake Fen	3a	Lake	pond, sedge meadow
Volo Bog	3a	Lake	pond
Wadsworth Prairie*	3a	Lake	marsh, wet prairie
Wauconda Bog*	3a	Lake	marsh
Exner Marsh	3a	McHenry	water marsh, shallow ponds
Glacial Rock	3a	McHenry	sedge meadow, marsh
Kettle Moraine	3a	McHenry	pond, marsh, sedge meadow
Lake-in-the-hills Fen	3a	McHenry	sedge meadow, marsh
Oakwood Hills Fen	3a	McHenry	sedge meadow
Pistakee Bog	3a	McHenry	pond, marsh, sedge meadow
Lockport Prairie	3a	Will	marsh, sedge meadow
Thorn Creek Woods	3a	Will	wet prairie
Wilmington Shrub Prairie	3a	Will	wet prairie, sedge meadow, marsh

Nature Preserve	Natural division	County	Wetland communities
Illinois Beach	3b	Lake	sedge meadow, marsh, pond
Cranberry Slough	3c	Cook	sedge meadow, marsh
Gensburg-Markham Prairie	3c	Cook	sedge meadow
Paw Paw Woods	3c	Cook	floodplain forest
Thornton-Lansing Road	3c	Cook	marsh, sedge meadow
Rockton Bog	3d	Winnebago	sedge meadow
Wilkinson-Renwick Marsh	4a	DeKalb	marsh
Goose Lake Prairie	4a	Grundy	marsh
Maramech Woods	4a	Kendall	sedge
Calamus Lake	4a	Macon	pond
Mehls Bluff	4a	Tazewell	floodplain forest
Grant Creek Prairie	4a	Will	wet prairie
O'Hara Woods	4a	Will	floodplain
Raccoon Grove	4a	Will	floodplain forest
Kankakee River	4a, 4e	Kankakee, Will	pond, marsh, floodplain forest
Bonnie's Prairie	4e	Iroquois	sand pond; wet sand prairie
Gooseberry Island	4e	Kankakee	wet floodplain forest
Momence Wetlands	4e	Kankakee	wet floodplain forest
Braidwood Dunes and Savanna	4e	Will	sedge meadow, marsh
Wilmington Shrub Prairie	4e	Will	sedge meadow, marsh
Matanzas Prairie	6a	Mason	wet sand prairie
Shick Shack Sand Pond	6a	Cass	pond, shrub swamp
Massasauga Prairie	7a	Warren	wet prairie
Julius J. Knobeloch Woods	9a	St. Clair	wet floodplain forest;
Miller Shrub Swamp	9b	Marion	pond, shrub swamp
Chauncy Marsh	10a	Lawrence	marsh
Rocky Branch	10b	Clark	floodplain
Forest Glen Seep	10c	Vermilion	marsh, floodplain forest
La Rue Swamp	12b	Union	pond, shrub swamp
Cave Creek Glade	13b	Johnson	wet floodplain forest
Heron Pond-Little Black Sough	13b	Johnson	wet floodplain forest, pond, swamp, shrub swamp
Section 8 Woods	14a	Pulaski	swamp
Halesia	14b	Massac	wet floodplain forest
Horseshoe Forest	14b	Alexander	wet floodplain forest, swamp
Mermet Swamp	14b	Massac	swamp

* No trail system (Almond Marsh); no developed access (Wadsworth Prairie and Wauconda Bog)

Literature Cited

McFall, D., and J. Karnes, eds. 1995. A directory of Illinois nature preserves. Volumes 1 and 2. Illinois Department of Natural Resources, Springfield, Illinois.

Appendix R: Elements of a Monitoring Plan

The monitoring plan or proposal presents examples regarding the project goals, objectives, performance standards, monitoring tasks, and monitoring methods. These elements for two hypothetical projects are presented below. The format presented is appropriate for a monitoring report.

PLANNED WETLAND NO. 1
Project Goal: Storm water retention

Objective: create 1.6 ha (4.0 ac) of floodplain forest that retains water after heavy rains

- Performance standards: after heavy rains, at least 0.6 m (2 ft) of water stands in the wetland

- Monitoring task: monitor stage gages

- Monitoring methods: stage gages installed through out the wetland, to be read monthly throughout the year

PLANNED WETLAND NO. 2
Project Goal: create habitat for a state threatened species, the Illinois chorus frog

Objective 1: create shallow open water wetlands with sand substrate and specified flooding regime at a specific compensation ratio

- Performance standards:
  — Emergent vegetation established in wetland
  — Wetland standing water levels are less than 0.6 m (2 ft) throughout the winter. Standing water persists until at least May in most years
  — Substrate is composed of loose finely-textured sand

- Monitoring tasks:
  — Monitor development of the wetland plant community
  — Monitor stage gages in wetland
  — Monitor substrate soil texture

- Monitoring methods:
  — Complete annual vegetation cover type maps for area
  — Determine vegetation species diversity, cover, and frequency by establishing permanent transects in the wetland. Vegetative species freqency and cover will be recorded annually within 1/4 m^2 (2.7 ft^2) plots spaced at 2 m (6.6 ft) intervals along transects
  — Annually photograph site from permanent stations
  — Install stage gages in constructed wetland and monitor them at least monthly
  — Analyze substrate texture after first year of project completion and every three years thereafter

Objective 2: Create 200-m- (650-ft-) wide sand prairie buffer adjacent to wetland

- Performance standards:
  — 70% of the total number of seeded prairie species become established
  — Seeded plant species compose 70% of vegetative cover

- Monitoring task: Monitor vegetation in prairie

- Monitoring methods:
  — Complete annual vegetation cover type maps for area
  — Determine vegetation species diversity, cover, and frequency by establishing permanent transects in the wetland. Vegetative species freqency and cover will be recorded annually within 1/4 m^2 (2.7 ft^2) plots spaced at 2 m (6.6 ft) intervals along transects
  — Annually photograph site from permanent stations

Appendix S: Site Management Goals

Prepared by:________________________ Date:________________________

Site name:________________________ County:________________________

Landowner:________________________ Manager:________________________

Site goals:________________________

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Permit requirements:________________________

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Management goals:________________________

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Potential threats to achieving management goals:________________________

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Management schedule has been reviewed by (check appropriate ( ), sign and date):________________________

( ) Landowner:________________________ Date:________________________

( ) Manager:________________________ Date:________________________

( ) Other:________________________ Date:________________________

Appendix T: Site Management Schedule

This management schedule is modified from Illinois Nature Preserves Commission (1991) and The Nature Conservancy (1991).

Site name:____________________ Time period (years):____________________ Date:__________ Page __ of __

County:____________________ Prepared by:____________________

Map symbol: management unit (list all communities)and tracked E/T species in unit under unit name.	Management objective	Management activity	Schedule (month/year)	Key personnel

Literature cited

Illinois Nature Preserves Commission. 1991. Management schedules and goals: a primer. Unpublished document.

The Nature Conservancy. 1991. Steward's handbook. Illinois Chapter, Chicago, Illinois.

Example management schedule
Site name: Restored Marsh
County: Cook County, Illinois

Time period (years): 1995 - 2000
Prepared by: Morris and Admiraal

Date: 3/1995

Page 1 of 1

Map symbol: management unit (list all communities and tracked E/T species in unit under unit name)	Management objective	Management activity	Schedule (month/year)	Key personnel
A: General	Regular site surveillance	Conduct semi-annual site visits	Spring and summer	IDOT, IDNR
Wet prairie Cattail marsh	Coordinate activities among agencies (IDOT, IDNR)	Review work plans at resource meetings	Midwinter	IDOT, IDNR
Open water Old field buffer Yellow-headed blackbird	Ensure water quality in wetland	Conduct quarterly water sampling	4X/year	IDOT
B: Wet prairie/sedge meadow	Establish wet prairie/sedge meadow vegetation	Drill seed in first year; monitor growth in subsequent years	Plant in spring; monitor in midsummer	IDOT; IDNR
	Create habitat for high quality plant species	Conduct site visits to verify species presence	Midsummer	IDNR
C: Cattail marsh	Control encroachment of cattails into wet prairie	Cut and apply herbicide	Late summer, early autumn	IDOT
	Encourage habitat for yellow-headed blackbird	Cut openings in marsh near open water	Late summer, early autumn	IDOT
D: Old field buffer	Establish native prairie vegetation	Drill seed prairie in first year; monitor in subsequent years	Plant in spring; monitor in midsummer	IDNR
	Control common buckthorn	Cut shrubs and apply herbicide to cut stumps	Midwinter	IDNR

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